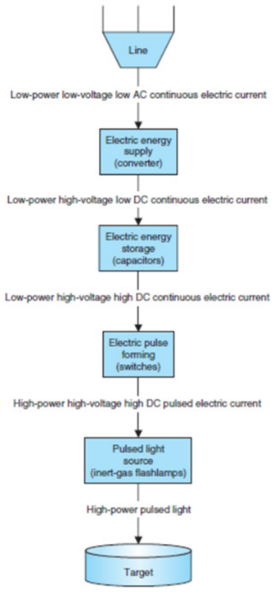
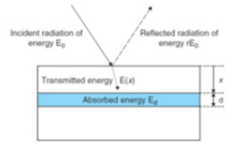
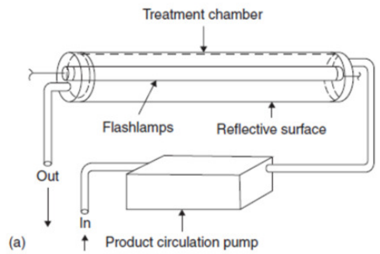
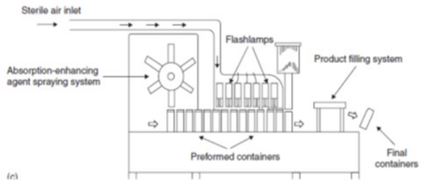


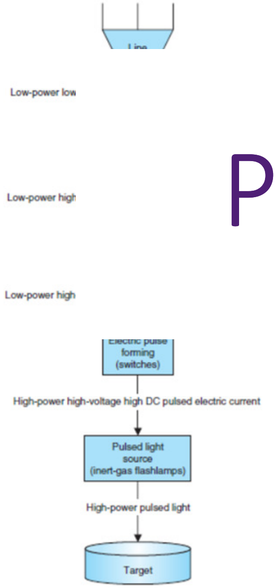


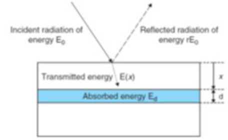
PROCESSAMENTO POR PULSO DE LUZ

Profa. Dra. Cynthia Ditchfield



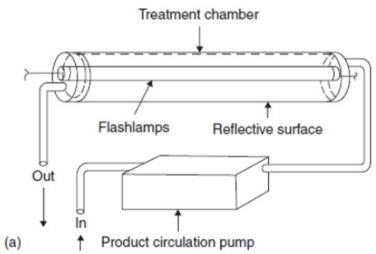


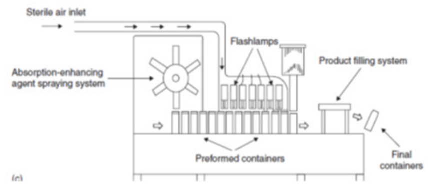


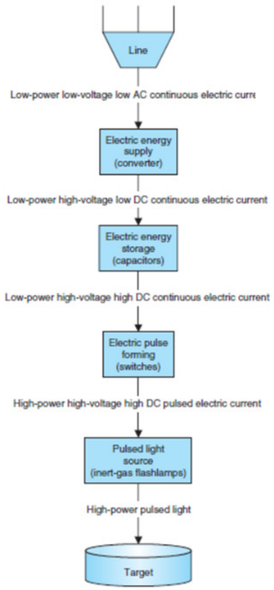


Processamento por Pulso de Luz

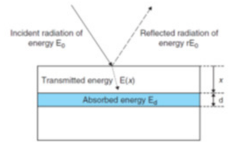
- Conceitos
- Equipamentos
- Aplicações





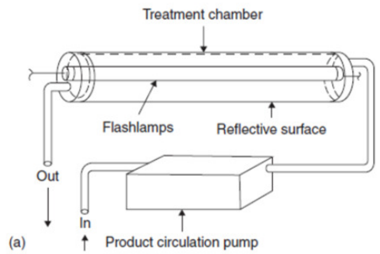


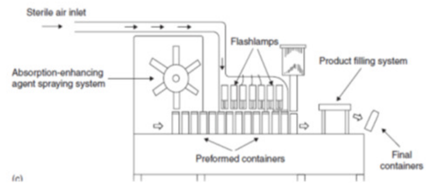
Processamento por Pulso de Luz



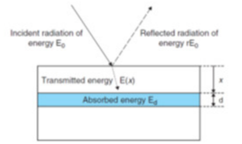
- Aplicação de pulsos de luz de altíssima potência e curtíssima duração emitidos por lâmpadas de descarga de gás inerte

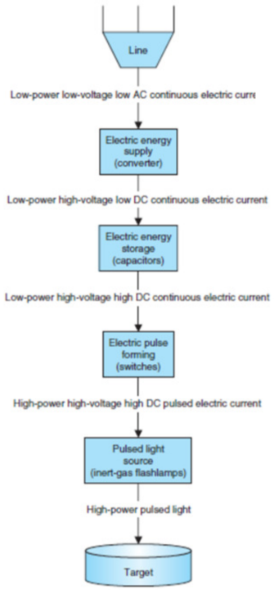
- Conversão de pulsos elétricos (*PEF*) em pulsos de radiação no espectro da luz **ultravioleta**, visível e infravermelha



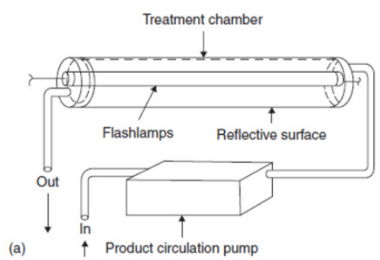


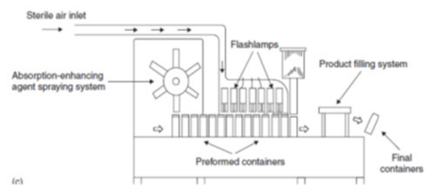
Processamento por Pulso de Luz

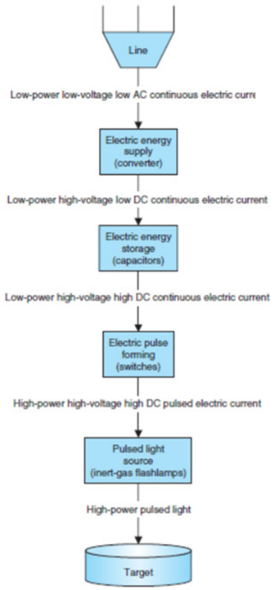




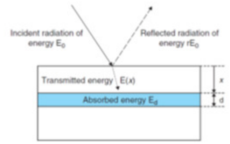
- ➢Purificação e esterilização de alimentos e itens relacionados
- ➢Inativação enzimática e microbiana
- ➢Efeito bactericida da luz **ultravioleta** contínua



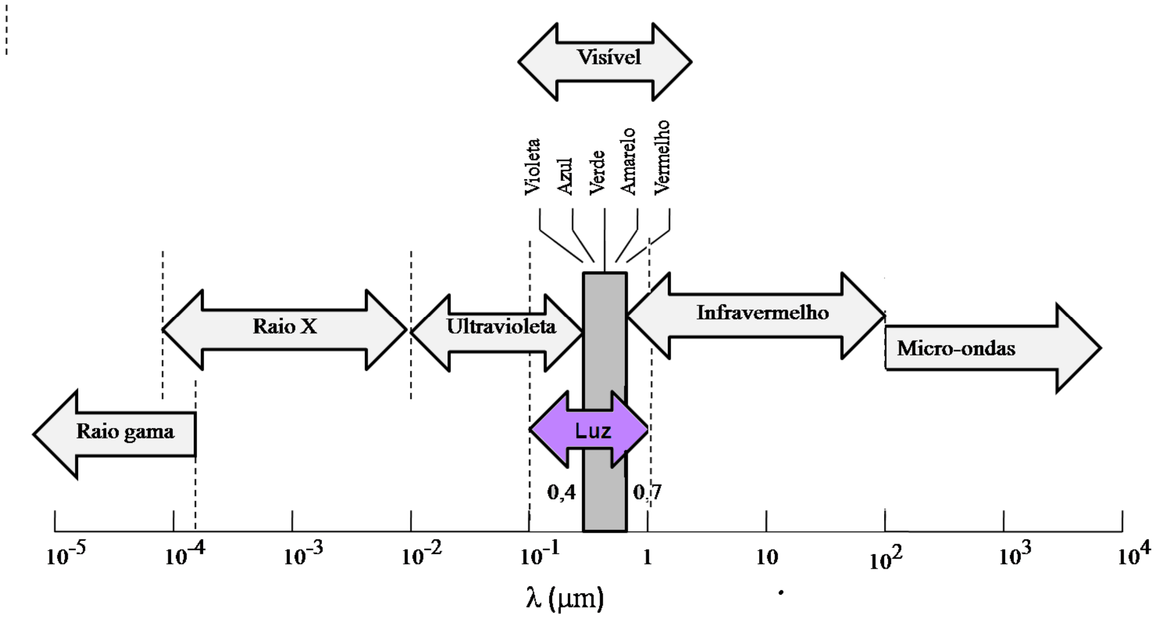


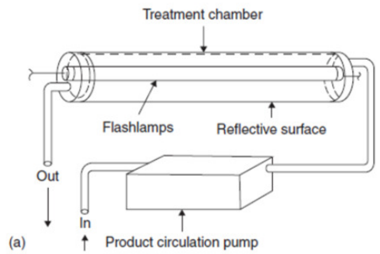


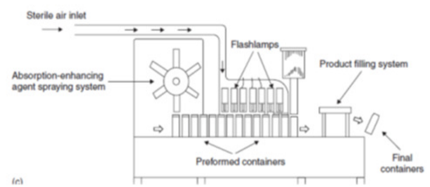
Processamento por Pulso de Luz

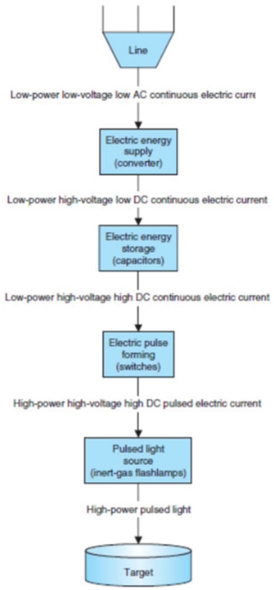


- Luz comprimentos de onda entre (180-1100) nm

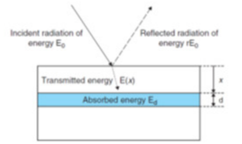








Processamento por Pulso de Luz



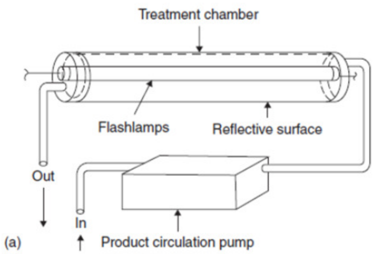
➢ Luz comprimentos de onda entre (180-1100) nm

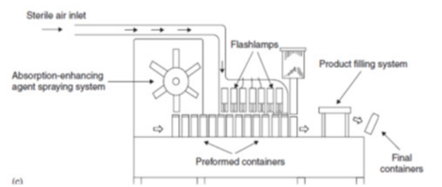
✓ Ultravioleta: (180-400) nm

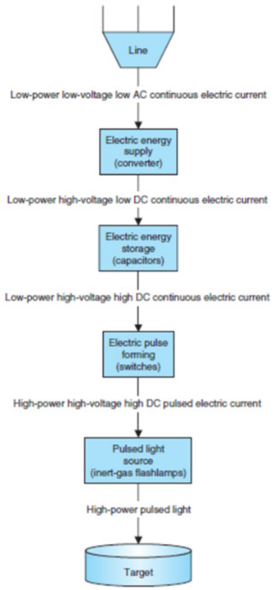
- UVA: (315-400) nm
- UVB: (280-315) nm
- UVC: (180-280) nm

✓ Visível: (400-700) nm

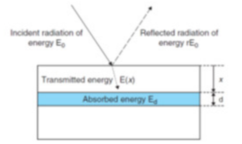
✓ Infravermelho: (700-1100) nm



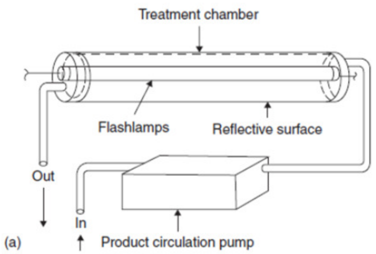


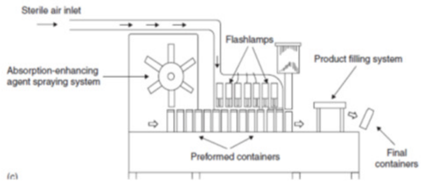


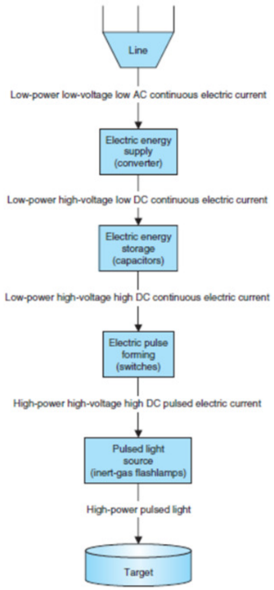
Processamento por Pulso de Luz

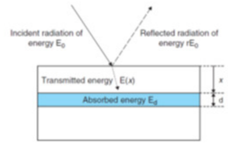


- Leis Fundamentais:
  - ✓ Radiação eletromagnética propagada por ondas
  - ✓ Energia das moléculas em estados quânticos:
    - Vibracional
    - Rotacional
    - Translacional
    - Eletrônica





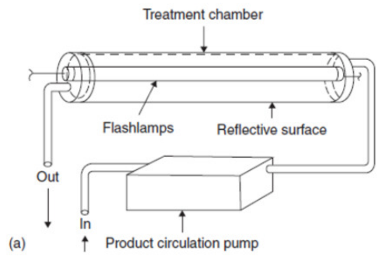


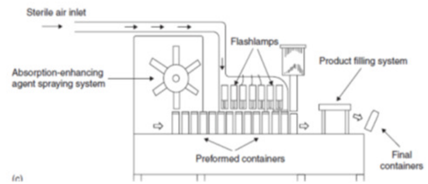


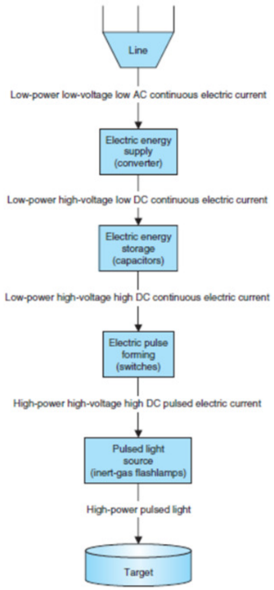
Processamento por Pulso de Luz

➢ Leis Fundamentais:

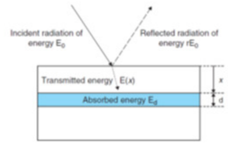
- ✓ Passagem entre estados quânticos por absorção ou emissão de energia radiante
- ✓ Luz é emitida de diferentes fontes por diferentes mecanismos a partir da transição espontânea de átomos de um estado excitado para uma condição de menor energia







Processamento por Pulso de Luz

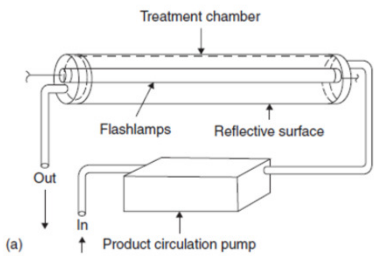


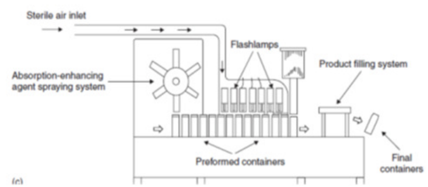
✓A energia radiante é transportada por fótons

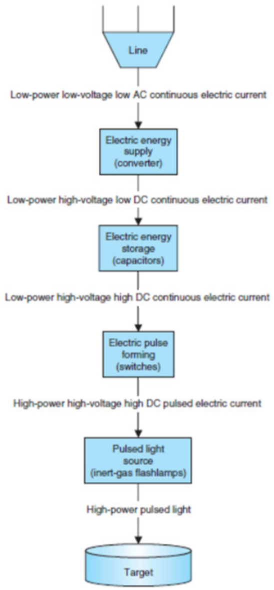
✓Função da frequência da onda

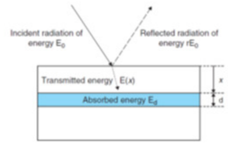
$$Q = h_P f$$

- em que: Q é a energia radiante [J]; h_P é a constante de *Planck* [$6{,}6261\times10^{-34}$ J•s] e f é a frequência da onda [Hz ou s^{-1}]







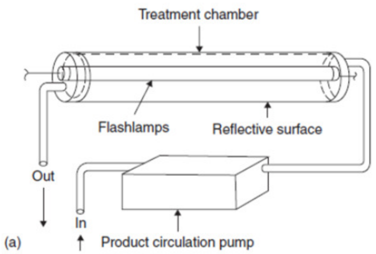


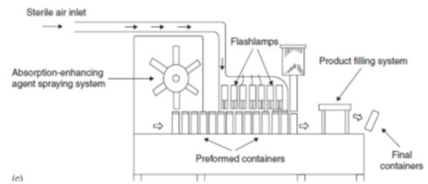
Processamento por Pulso de Luz

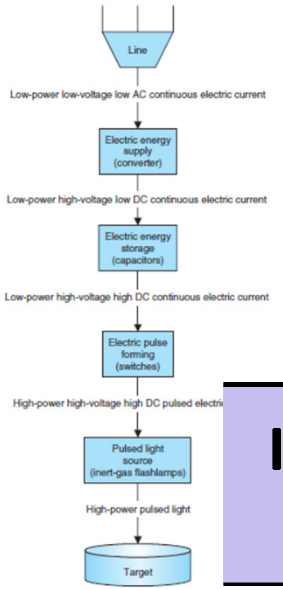
✓Relação da frequência com o comprimento da onda

$$f = \frac{c}{\lambda}$$

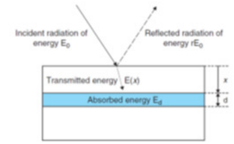
- em que: *c* é a velocidade da luz no vácuo [$2{,}9979 \times 10^{8}$ m.s^{-1}] e λ é o comprimento de onda [µm]





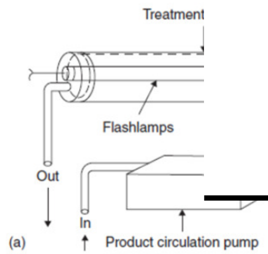


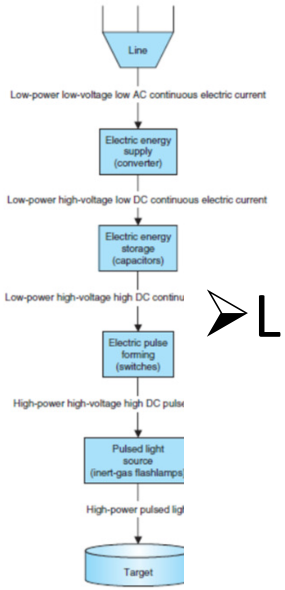
Processamento por Pulso de Luz

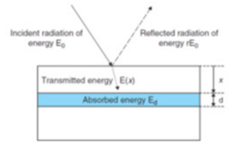


Relação entre cada intervalo de comprimento de onda (λ) e os mecanismos de absorção de energia

Intervalo do λ [μm]	Espectro	Mecanismo de absorção de energia
0,2 – 0,7	Ultravioleta e luz visível	**Alteração no estado eletrônico**
2,5 – 100	Parte da região infravermelha	Alteração no estado vibracional
>100	Região das micro-ondas	Alteração no estado rotacional

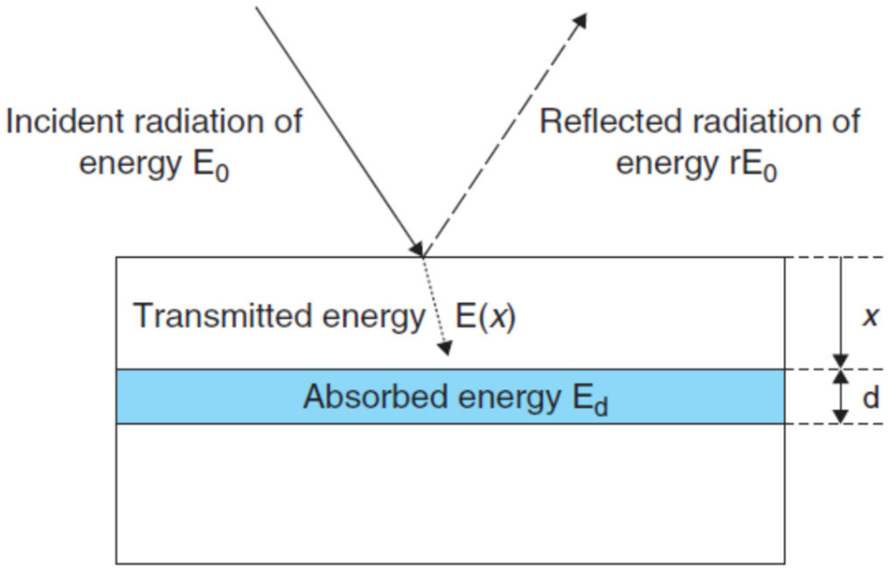


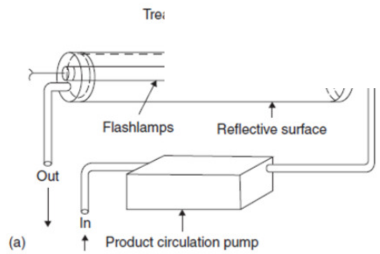


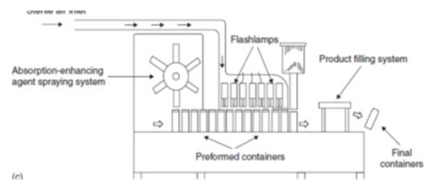


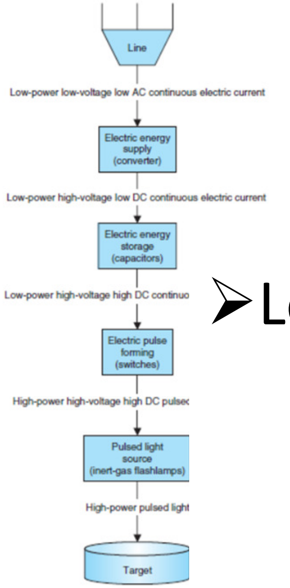
Processamento por Pulso de Luz

- Luz incidente no material: refletida, transmitida e absorvida

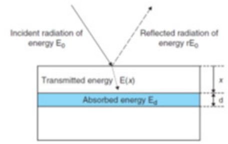








Processamento por Pulso de Luz

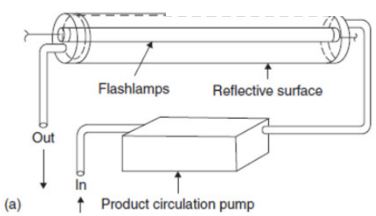


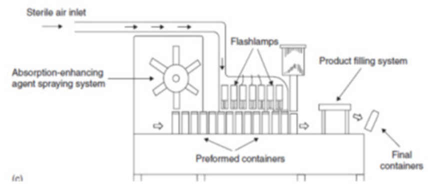
➢Leis Fundamentais:

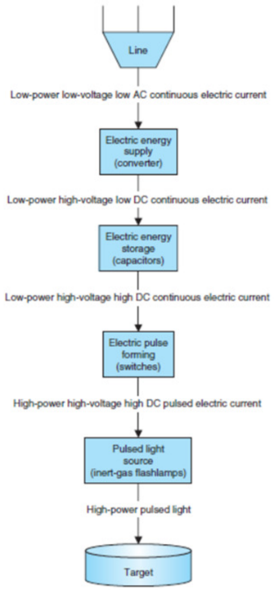
✓A energia transmitida *E*(*x*) até uma distância *x* abaixo da superfície do material diminui de acordo com a Lei de *Lambert-Beer*

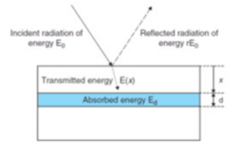
✓$E(x) = (1 - r)E_0 e^{-\alpha x}$

- Em que *r* é o coeficiente de reflexão do material, E_0 é a energia incidente, α é o coeficiente de extinção (transparência ou opacidade do material em cada λ)







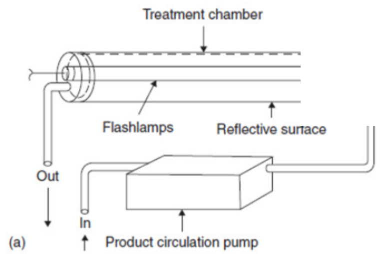


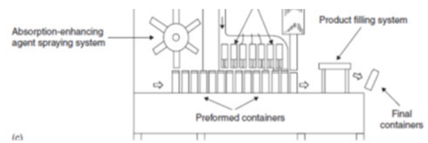
Processamento por Pulso de Luz

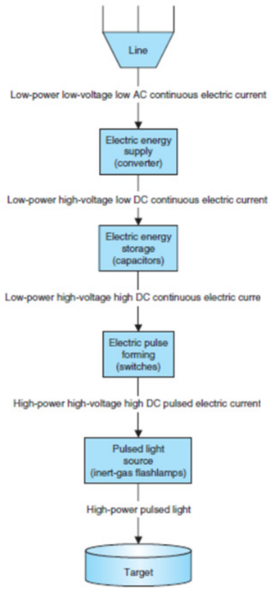
➢Leis Fundamentais:

✓A energia absorvida (E_d) por uma camada de espessura *d* abaixo da distância *x* é:

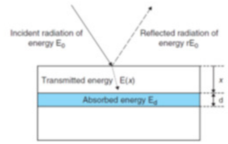
✓$E_d = E(x)\left(1 - e^{-\alpha d}\right)$







Processamento por Pulso de Luz

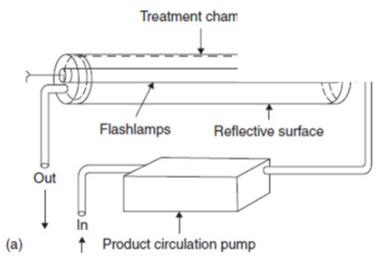


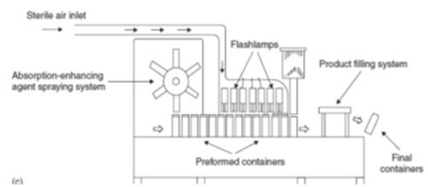
➢ Leis Fundamentais:

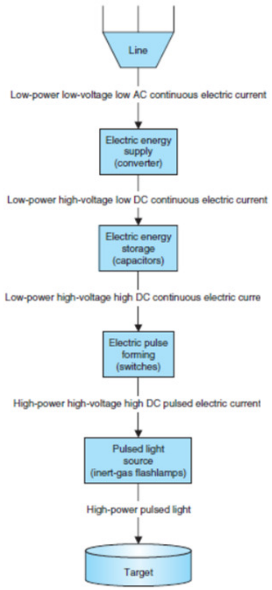
✓ A energia absorvida (E_d) é dissipada na forma de calor resultando num aumento de temperatura

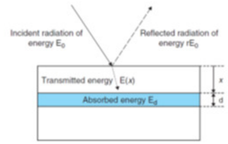
✓ $$\Delta T = \frac{E_d}{\rho C_p A d}$$

- Em que ρ é a densidade do material, C_p é o calor específico do material, *A* é a área superficial







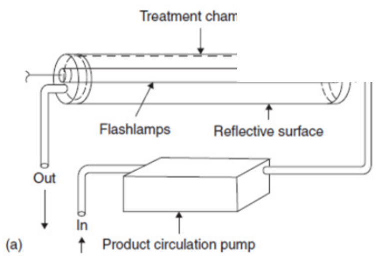


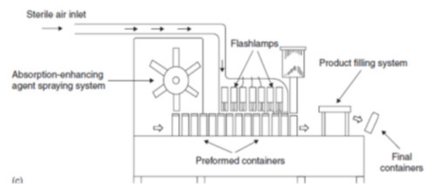
Processamento por Pulso de Luz

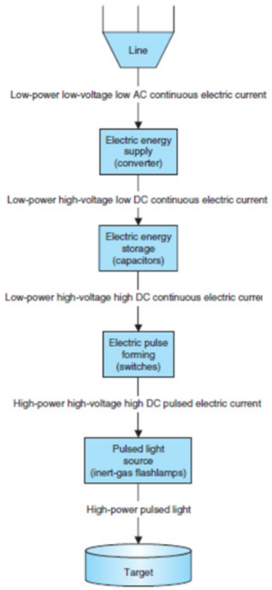
➢ Leis Fundamentais:

✓ O aumento de temperatura e a taxa de transferência de calor dependem da intensidade , da duração da radiação incidente e das propriedades termofísicas do material

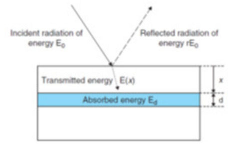
✓ A energia que chega numa unidade de área superficial é denominada densidade energética ou fluência (*F*) em kJ/m²







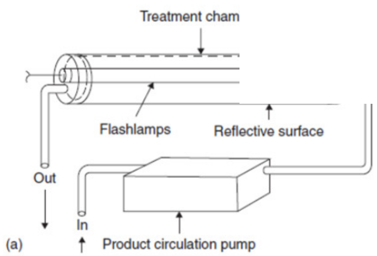
Processamento por Pulso de Luz

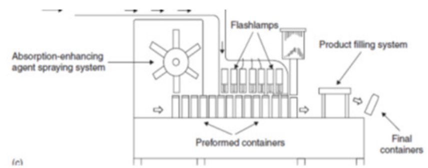


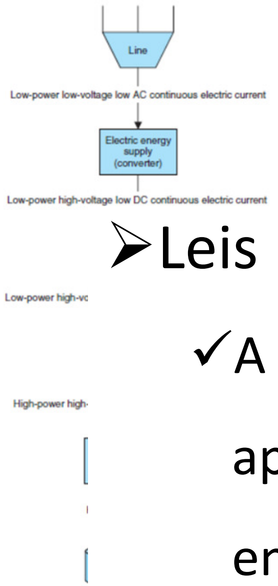
➢ Leis Fundamentais:

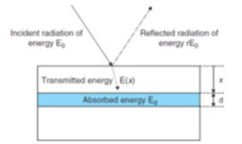
✓ A luz pode ser empregada de forma contínua ou na forma de pulsos

✓ Para um processo de *n* pulsos cada um com duração *t* e fluência *F* o tempo total de processo é dado por $t_{tot} = n.t$, a fluência total será $F_{tot} = n.F$ e a taxa de fluência será $F_r = \frac{F}{t}$ em kW/m²





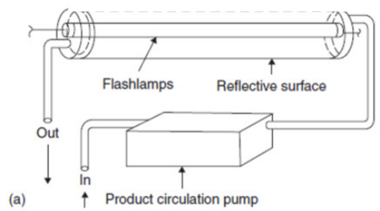


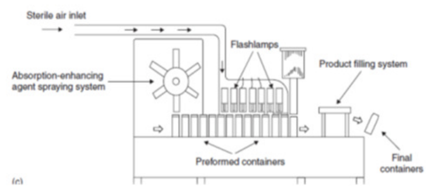


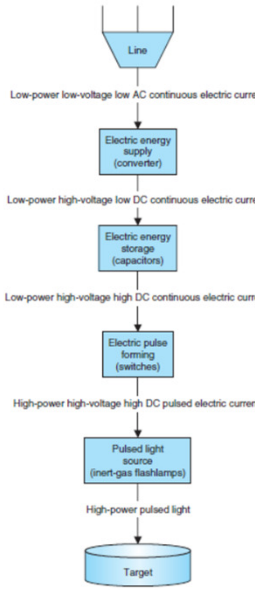
Processamento por Pulso de Luz

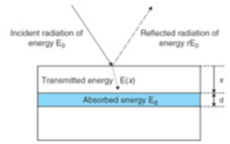
➢ Leis Fundamentais:

✓ A aplicação da energia na forma de pulsos resulta numa potência aplicada muito maior do que a aplicada na forma contínua (mesma energia total equivalente)









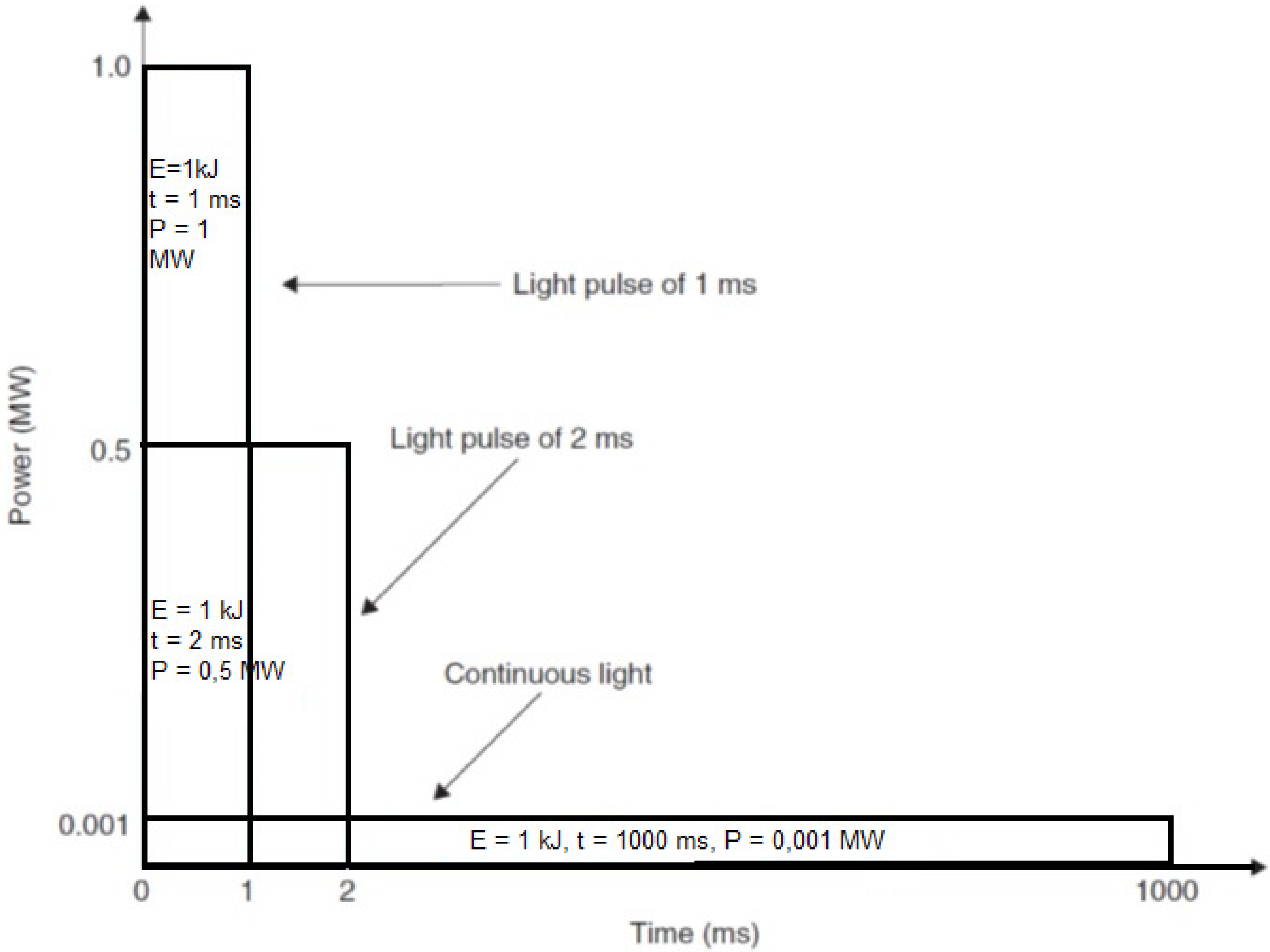
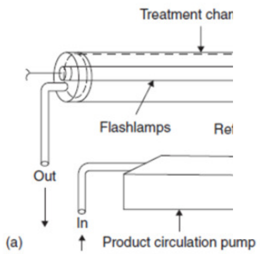
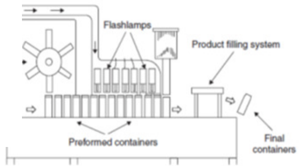
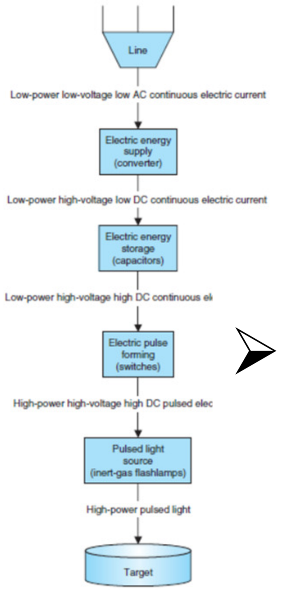


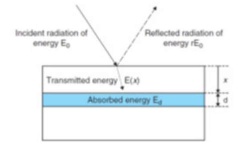
Figure 11.2 Power delivered by continuous light and light pulses of different duration, having equal energy content.







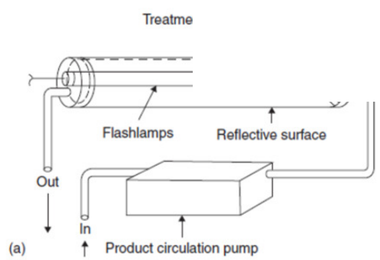
Processamento por Pulso de Luz

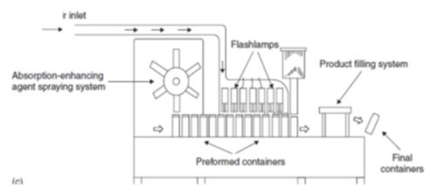


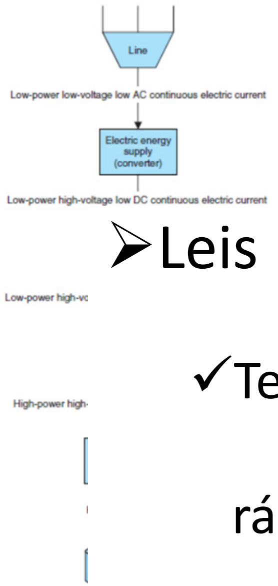
- ➢Leis Fundamentais:

  ✓Quanto mais curto o pulso maior a potência

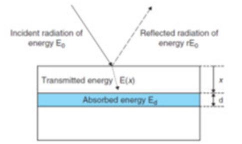
  ✓Poder de penetração nos materiais da luz pulsada é muito maior que da contínua





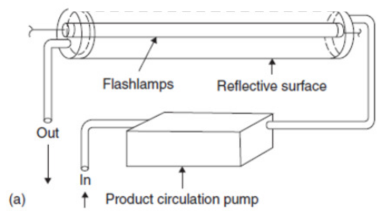


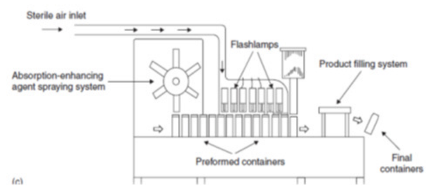
Processamento por Pulso de Luz

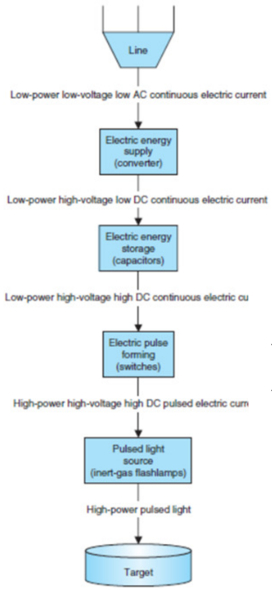


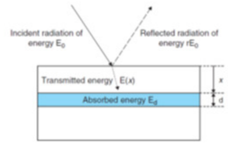
➢ Leis Fundamentais:

✓ Tempo reduzido para a transferência de calor por condução: aumento rápido da temperatura local para valores mais elevados que quando da aplicação contínua da luz sem aumento significativo da temperatura média





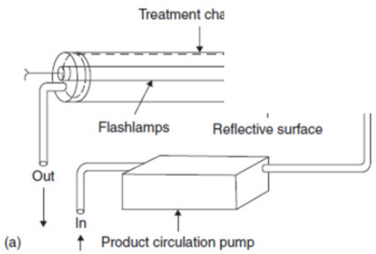


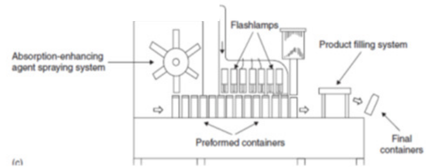


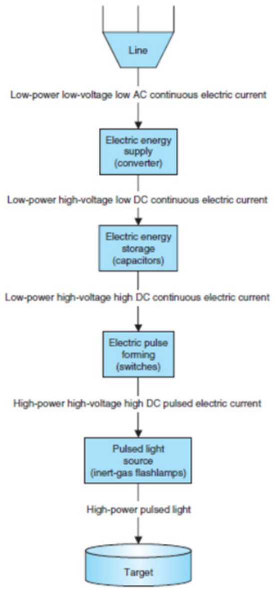
Processamento por Pulso de Luz

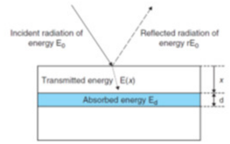
➢ Efeitos da luz pulsada nos microrganismos:

- ✓ Inativação microbiana por efeito fotoquímico e fototérmico
- ✓ Efeito fotoquímico absorção da luz UV pelo DNA microbiano impedindo a transcrição de genes e a sua reprodução





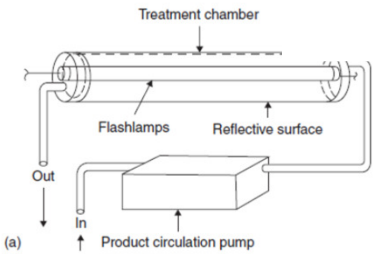


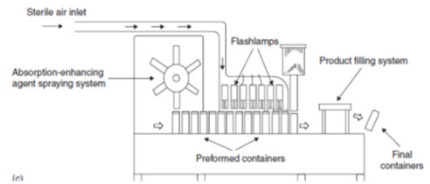


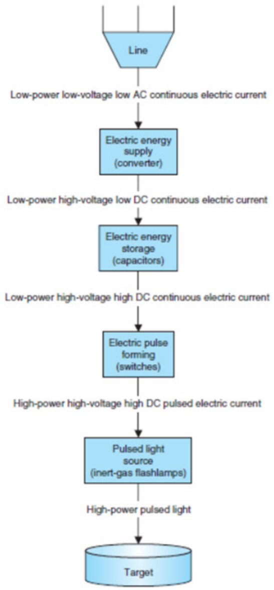
Processamento por Pulso de Luz

➢ Efeitos da luz pulsada nos microrganismos:

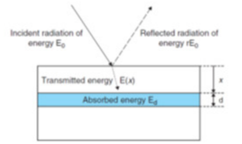
✓ O pulso de luz é mais efetivo que a aplicação contínua da luz UV: maior potência causa danos irreversíveis que não permitem o reparo da célula e o curto tempo de duração evitam mecanismos de adaptação da célula







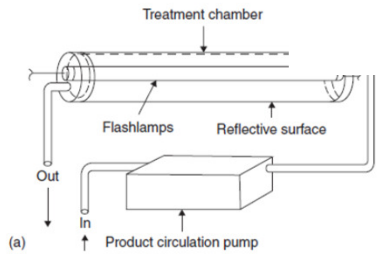
Processamento por Pulso de Luz

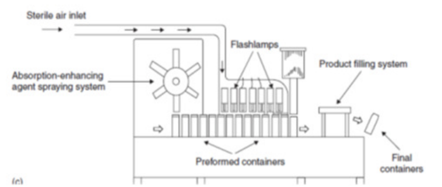


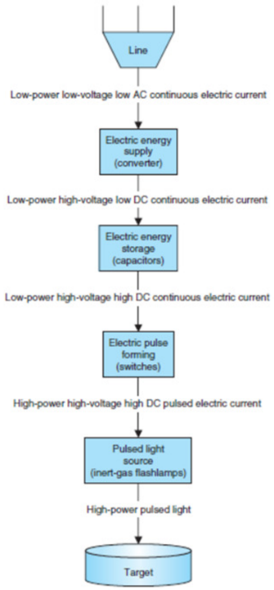
➢Efeitos da luz pulsada nos microrganismos:

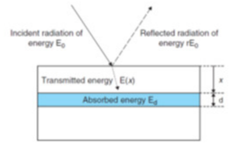
✓Efeito fototérmico células microbianas absorvem mais a luz pulsada que o meio e aquecem rapidamente de forma localizada sendo inativadas pelo calor

✓Efeito fotoquímico é maior que o fototérmico



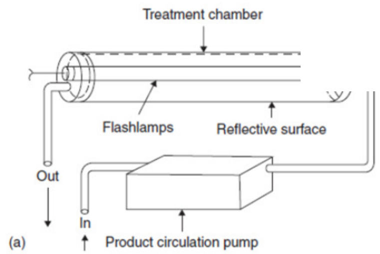


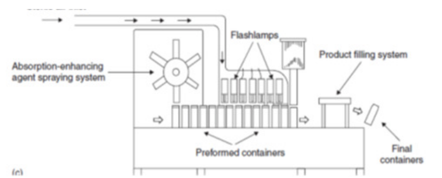


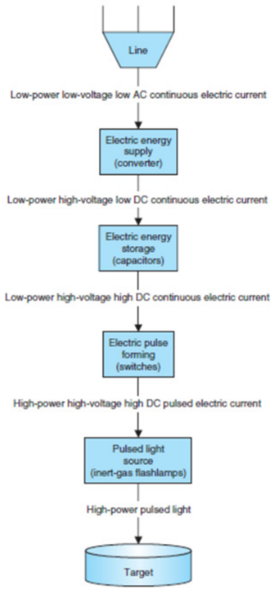


Processamento por Pulso de Luz

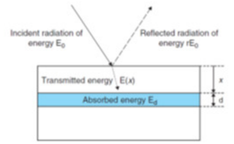
- ➢Efeitos da luz pulsada nos microrganismos:
  - ✓O efeito fotoquímico é devido principalmente à ação dos raios UVC que no entanto podem também causar danos fotoquímicos às células dos alimentos





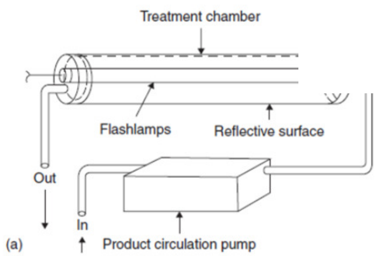


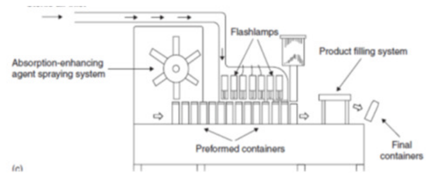
Processamento por Pulso de Luz

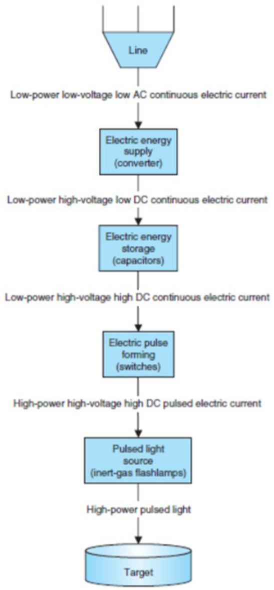


➢Efeitos da luz pulsada:

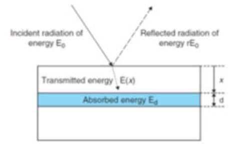
- ✓Pode-se trabalhar com pulso de luz de amplo espectro (*broad spectrum pulsed light BPSL*) que inclui todos os comprimentos de onda
- ✓Selecionar pela aplicação de filtros ou na conversão do pulso elétrico apenas os comprimentos de onda referentes ao UV (UV *pulsed light UVPL*)



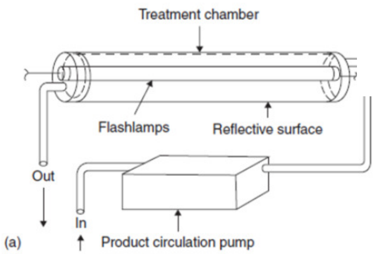


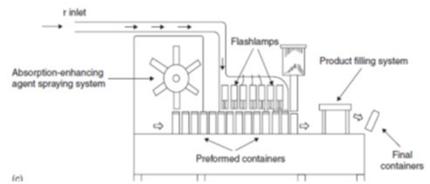


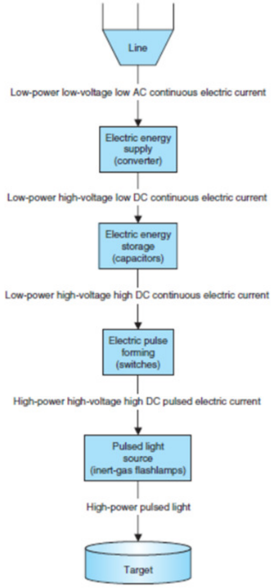
Processamento por Pulso de Luz



- Efeitos da luz pulsada :
  - ✓ Espectro de absorção do material a ser tratado
  - ✓ Compatibilizar os espectros de emissão da luz com o espectro de absorção







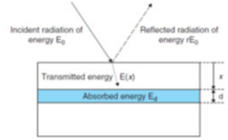
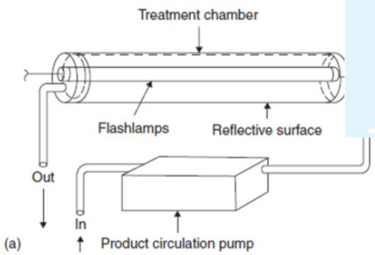
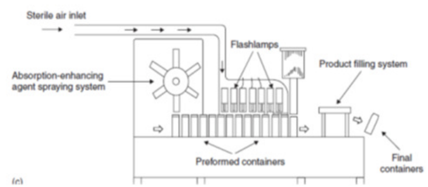


Table 11.1 A summary of selected scientific works about effects of PL on microorganisms in solid food items

Item	Experimentals	Results/remarks	Reference
Shrimp	BSPL $F = 1\text{–}2\,\mathrm{J/cm^2}$ $n = 4\text{–}8$	1–3 lcr[a] of *Listeria* (inoc.[b]), resulting in a shelf-life extension of 1 week versus untreated samples	Dunn et al. (1989)
Curds of dry cottage cheese	BSPL $F = 16\,\mathrm{J/cm^2}$, $n = 1\text{–}2$	1.5 lcr of *Pseudomonas* sp.[c]	Dunn et al. (1989)
Freshly baked cakes packaged in clear plastic containers	BSPL $F = 16\,\mathrm{J/cm^2}$ $n = 3$	Absence of moulds in treated samples after storage at room temperature for 11 days, while untreated samples were very mouldy	Dunn et al. (1989)
Hard crusted white bread rolls	BSPL $F = 16\,\mathrm{J/cm^2}$ $n = 1\text{–}2$	1.5 lcr of mould sp. with $n = 1$ and 2.7 lcr of mould sp. with $n = 2$	Dunn et al. (1989)
Packed white bread slices	BSPL	Fresh appearance for more than 2 weeks, without surface mould formation, while untreated samples were very mouldy	Rice (1994)



(a)



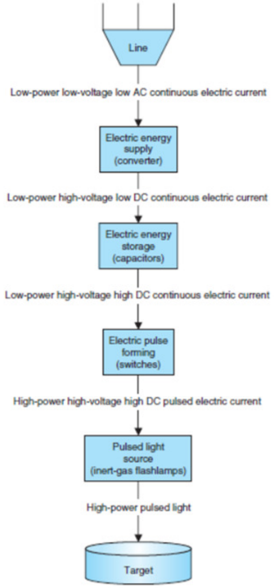
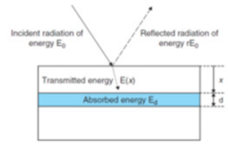
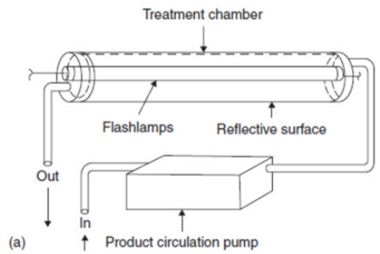
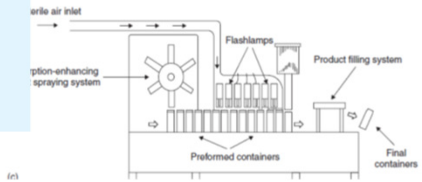


Table 11.1 A summary of selected scientific works about effects of PL on microorganisms in solid food items

Item	Experimentals	Results/remarks	Reference
Meat	BSPL	Reduction of *Listeria* and *Salmonella* population	Rice (1994)
Chicken wings	BSPL	2 lcr of *Salmonella* (inoc.)	Dunn et al. (1995)
Frankfurters	BPSL F up to 30 J/cm^2	2 lcr of *Lysteria innocua* (inoc.)	Dunn et al. (1995)
Retail meat	BSPL	1–3 lcr of total aerobic, lactic, enteric bacteria and *Pseudomonas*	Dunn et al. (1995)
Commercial or raw eggs	BSPL $F = 0.5$ J/cm^2, $n = 8$	Up to 8 lcr of *Salmonella enteriditis* (inoc.) Inactivation effect observed on eggshells and a little extended into the egg pores	Dunn (1996)
Wax-coated strawberries	BSPL $F = 0.5$ J/cm^2, $n = 4$	No mould growth after 2 weeks storage at room temperature	Dunn et al. (1996)
HDPE Prepackaged catfish fillets	BSPL $F = 0.25$–0.50 J/cm^2 $n = 2$–4	Psychrotropic (PPC) and coliform (TCC) bacteria were not reduced initially by any treatment. After one week of storage, PPC were 1 (in treated	Shuwaish et al. (2000)







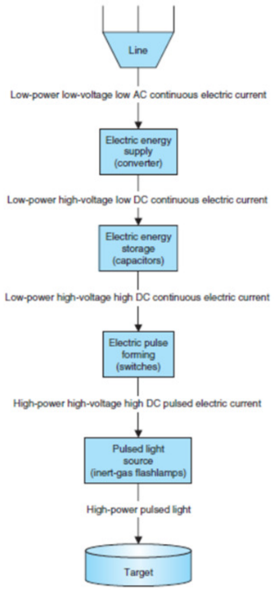
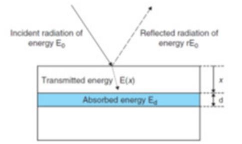
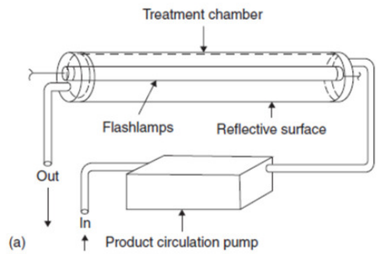


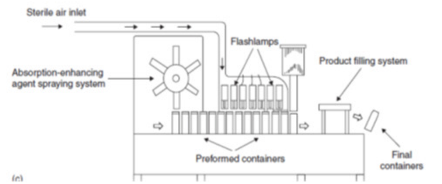
Table 11.1 ***(Continued)***

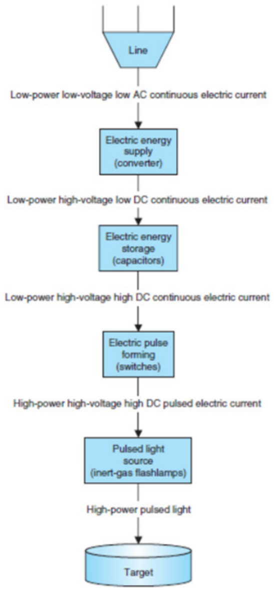
Item	Experimentals	Results/remarks	Reference
		samples with $F = 0.25$) or 2 (in treated samples with $F = 0.50$) log cfu/g lower than untreated samples, TCC were reduced from about 50 to less than 10 cfu/g	
Eggshells	BSPL $F = 1.5\,\text{J/cm}^2$ $n = 1$–6	lcr of *Bacillus subtilis* sp. (inoc.) ranging from 3 to 6 with *n* ranging from 2 to 6	Mimouni (2000)
Cake	BSPL $F = 1.5\,\text{J/cm}^2$ $n = 1$–16	lcr of *Aspergillus niger* sp. (inoc.) ranging from 3 to 6 with *n* ranging from 2 to 6 Shelf-life increased from 26 days for untreated samples to 6 months for treated samples	Mimouni (2000)
Packed slices of bread	BSPL $F = 1.5\,\text{J/cm}^2$	Shelf life increased from 16 days for untreated samples to 5 months for treated samples	Mimouni (2000)
Corn meal	UVPL	Up to 5 lcr of fungal sp. of *Aspergillus niger*	Jun et al. (2003)
Clover honey	UVPL $F = 5.6\,\text{J/cm}^2$ $n = 15$–540	Samples 2 mm deep: reduction of sp. of *Clostrydium sporogenes* (inoc.) ranging from 39.5 to 73.9% with *n* ranging from 135 to 405 Samples 8 mm deep: reduction of sp. of *Clostrydium sporogenes* (inoc.) ranging from 0 to 89.4% with n ranging from 15 to 540	Hillegas and Demirci (2003)

[a] = log cycle reduction; [b] = inoculated; [c] = spores.









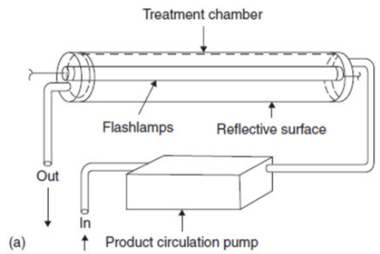
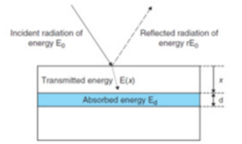
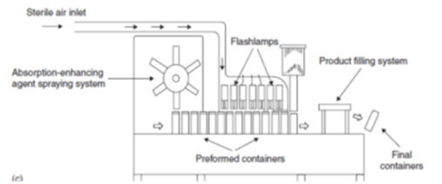


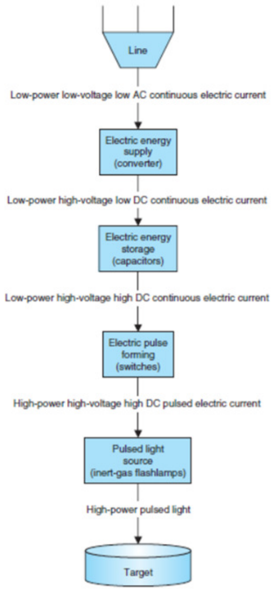
Table 11.1 *(Continued)*

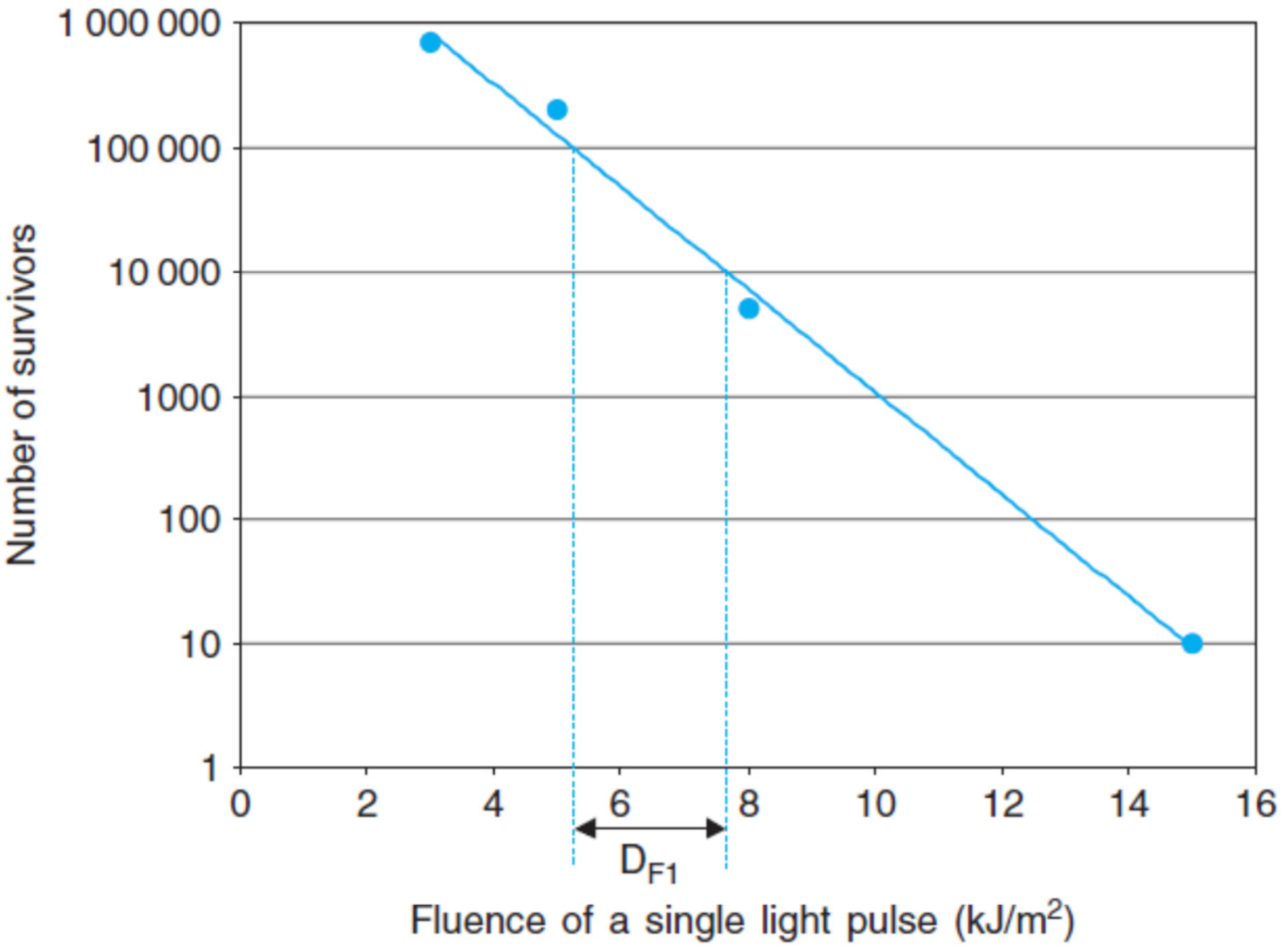
Item	Experimentals	Results/remarks	Reference
		samples with $F = 0.25$) or 2 (in treated samples with $F = 0.50$) log cfu/g lower than untreated samples, TCC were reduced from about 50 to less than 10 cfu/g	
Eggshells	BSPL $F = 1.5\,J/cm^2$ $n = 1–6$	lcr of *Bacillus subtilis* sp. (inoc.) ranging from 3 to 6 with *n* ranging from 2 to 6	Mimouni (2000)
Cake	BSPL $F = 1.5\,J/cm^2$ $n = 1–16$	lcr of *Aspergillus niger* sp. (inoc.) ranging from 3 to 6 with *n* ranging from 2 to 6 Shelf-life increased from 26 days for untreated samples to 6 months for treated samples	Mimouni (2000)
Packed slices of bread	BSPL $F = 1.5\,J/cm^2$	Shelf life increased from 16 days for untreated samples to 5 months for treated samples	Mimouni (2000)
Corn meal	UVPL	Up to 5 lcr of fungal sp. of *Aspergillus niger*	Jun et al. (2003)
Clover honey	UVPL $F = 5.6\,J/cm^2$ $n = 15–540$	Samples 2 mm deep: reduction of sp. of *Clostrydium sporogenes* (inoc.) ranging from 39.5 to 73.9% with *n* ranging from 135 to 405 Samples 8 mm deep: reduction of sp. of *Clostrydium sporogenes* (inoc.) ranging from 0 to 89.4% with n ranging from 15 to 540	Hillegas and Demirci (2003)

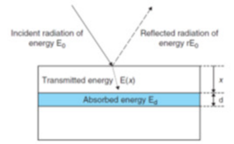
[a] = log cycle reduction; [b] = inoculated; [c] = spores.











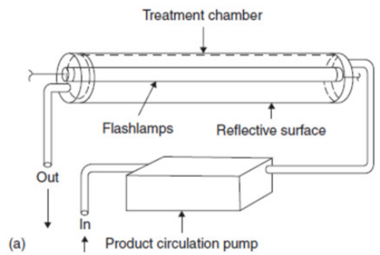
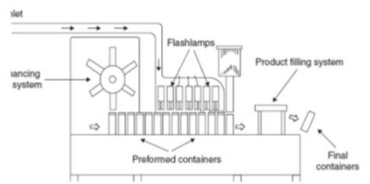
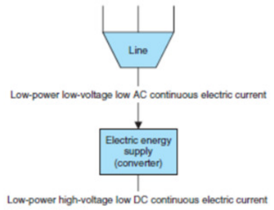
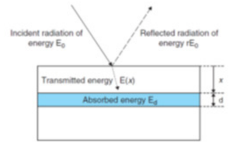


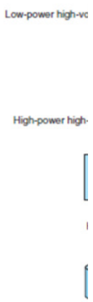
Figure 11.6 Example of relationship between pulsed light-induced microbial inactivation and fluence of a single light pulse.



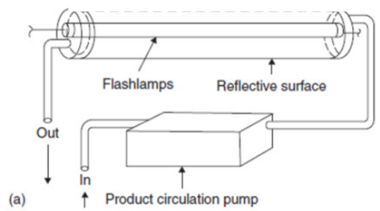


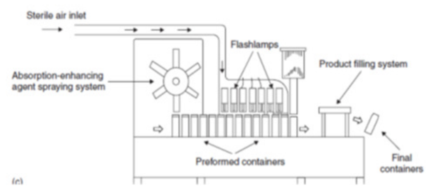


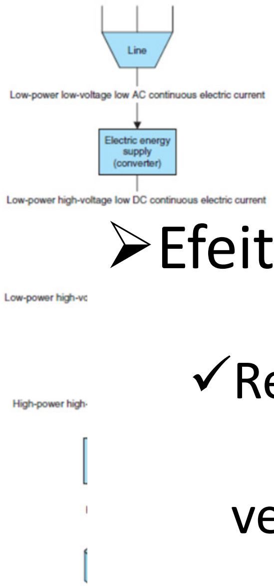
Processamento por Pulso de Luz

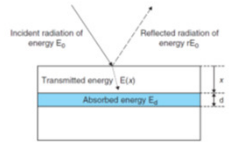


- ➢Efeitos da luz pulsada nos microrganismos:
  - ✓Evitar o aquecimento excessivo do alimento (menor que 50 °C)
  - ✓Tempo do pulso recomendado pelo *FDA* < 2ms com (1 a 20) pulsos por segundo





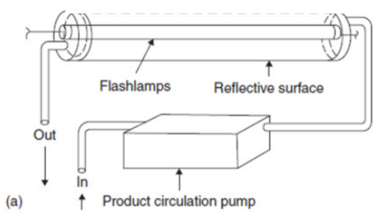


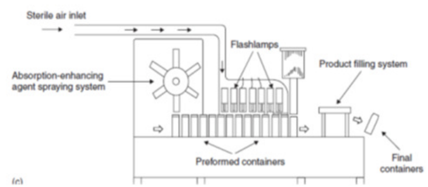


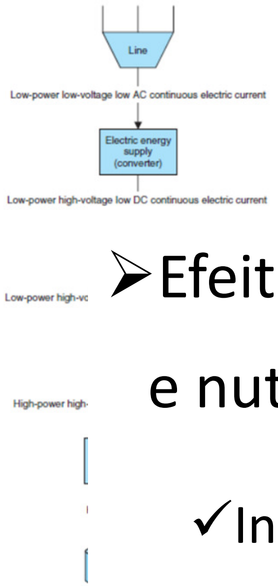
Processamento por Pulso de Luz

➢ Efeitos da luz pulsada nos microrganismos:

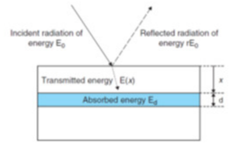
- ✓Resistências microbianas diferentes: tamanho, tipo de célula, forma vegetativa, etc.
- ✓Número mínimo de pulsos para obter alguma inativação
- ✓Alta transparência e baixo coeficiente de reflexão favorecem processo



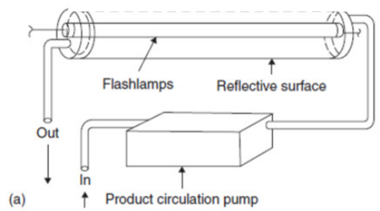


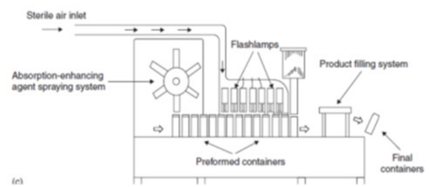


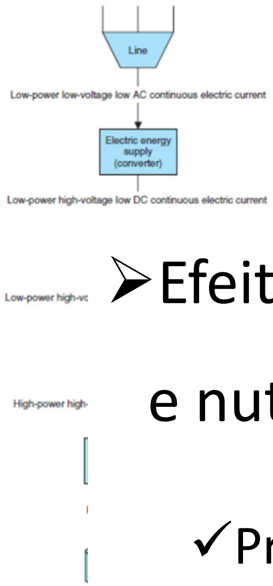
Processamento por Pulso de Luz

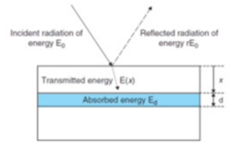


- Efeitos da luz pulsada em enzimas e nas propriedades sensoriais e nutricionais:
    - ✓Inativação enzimática efetiva por luz pulsada numa camada de 0,1 mm
    - ✓Poucos estudos contemplam propriedades sensoriais e nutricionais
    - ✓Concentração nutrientes pouco afetada (degradação de vitaminas)
    - ✓Catalisa a oxidação de lipídios



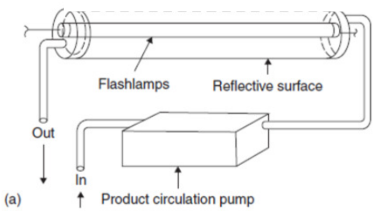


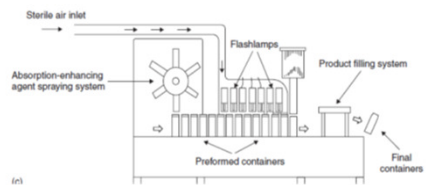


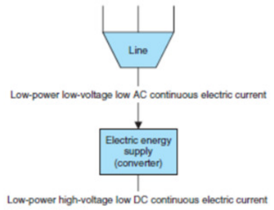


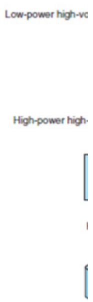
Processamento por Pulso de Luz

- ➢Efeitos da luz pulsada em enzimas e nas propriedades sensoriais e nutricionais:
  - ✓Propriedades sensoriais como cor e sabor sofreram pouca alteração
  - ✓Tratamento superficial

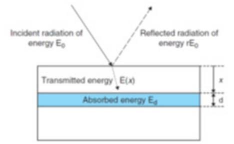




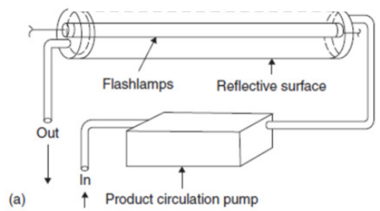


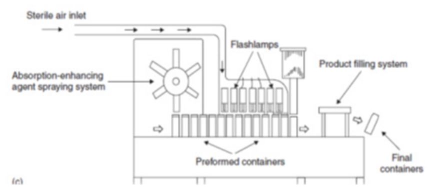


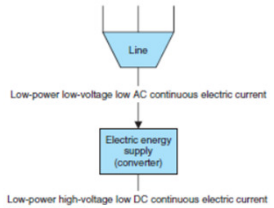
Processamento por Pulso de Luz

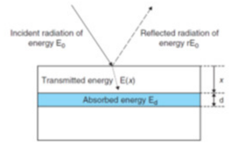


- Efeitos da luz pulsada em toxinas, contaminantes e outros compostos
  - ✓ Degradação fotoquímica de compostos nocivos (aflatoxina, patulina, ocratoxina, hidroximetilfurfural (HMF), pesticidas: tiabendazol, carbendazim e benomyl)
  - ✓ Degradação fotoquímica de pigmentos e produtos de reações de escurecimento enzimático e não enzimático



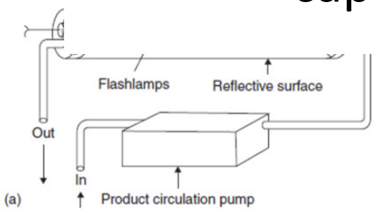


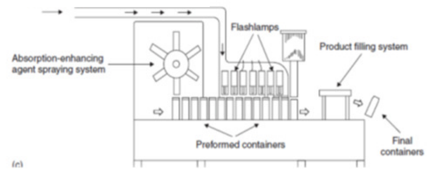


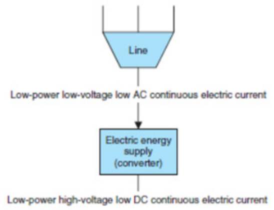


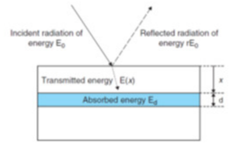
Processamento por Pulso de Luz

- Equipamentos:
  - ✓A geração de um pulso de luz envolve as seguintes etapas:
    - Obtenção de energia de uma fonte primária e conversão de baixa potência em corrente alternada para alta potência em corrente contínua
    - Acumulação desta energia e armazenamento temporário num banco de capacitores







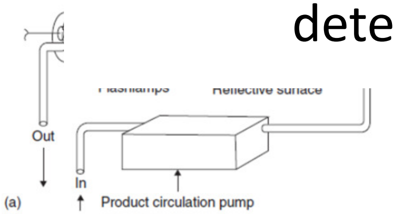


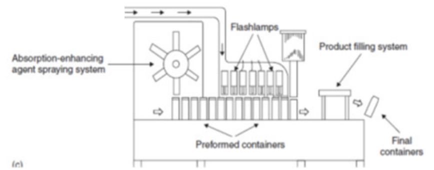
Processamento por Pulso de Luz

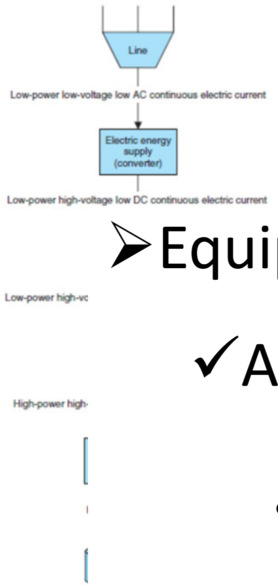
➢ Equipamentos:

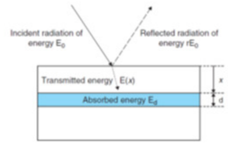
✓ A geração de um pulso de luz envolve as seguintes etapas:

- Conversão rápida da energia armazenada pelo acionamento de interruptores regulados por controladores que determinam a forma do pulso e as condições ideais de energia elétrica para gerar um pulso de luz de comprimento de onda otimizado para uma determinada aplicação



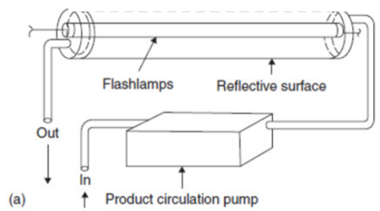


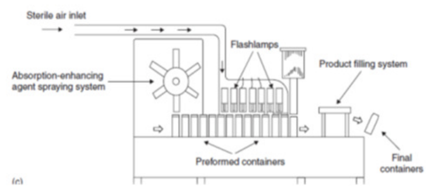


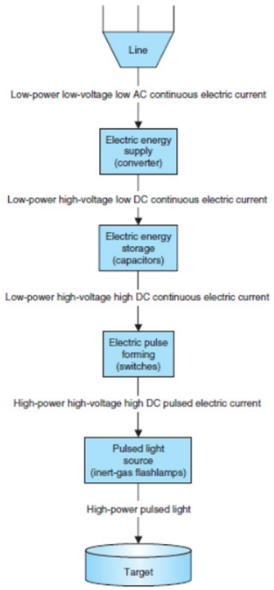


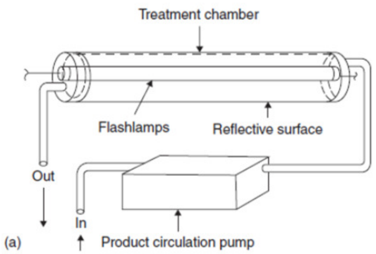
Processamento por Pulso de Luz

- ➢ Equipamentos:
  - ✓ A geração de um pulso de luz envolve as seguintes etapas:
    - O pulso elétrico de alta potência é convertido em luz pulsada por lâmpadas de descarga preenchidas com gás inerte
    - A energia é aplicada no alvo do tratamento









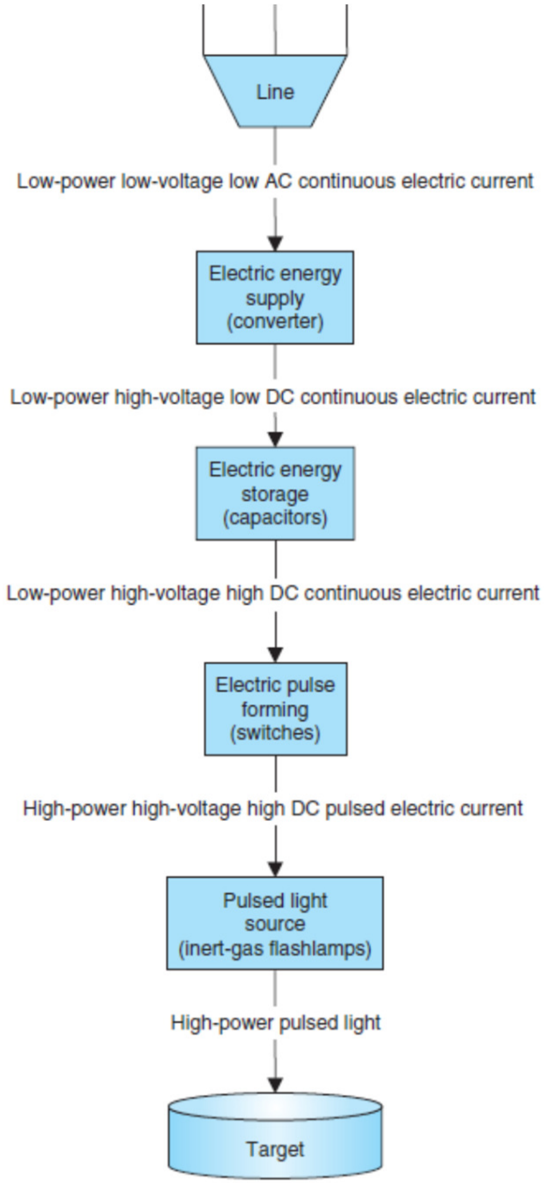
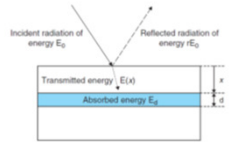
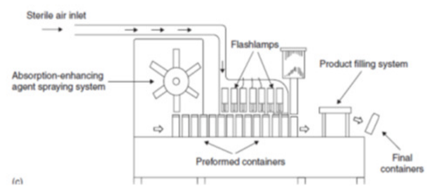
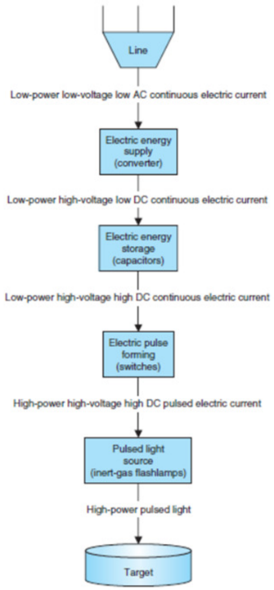
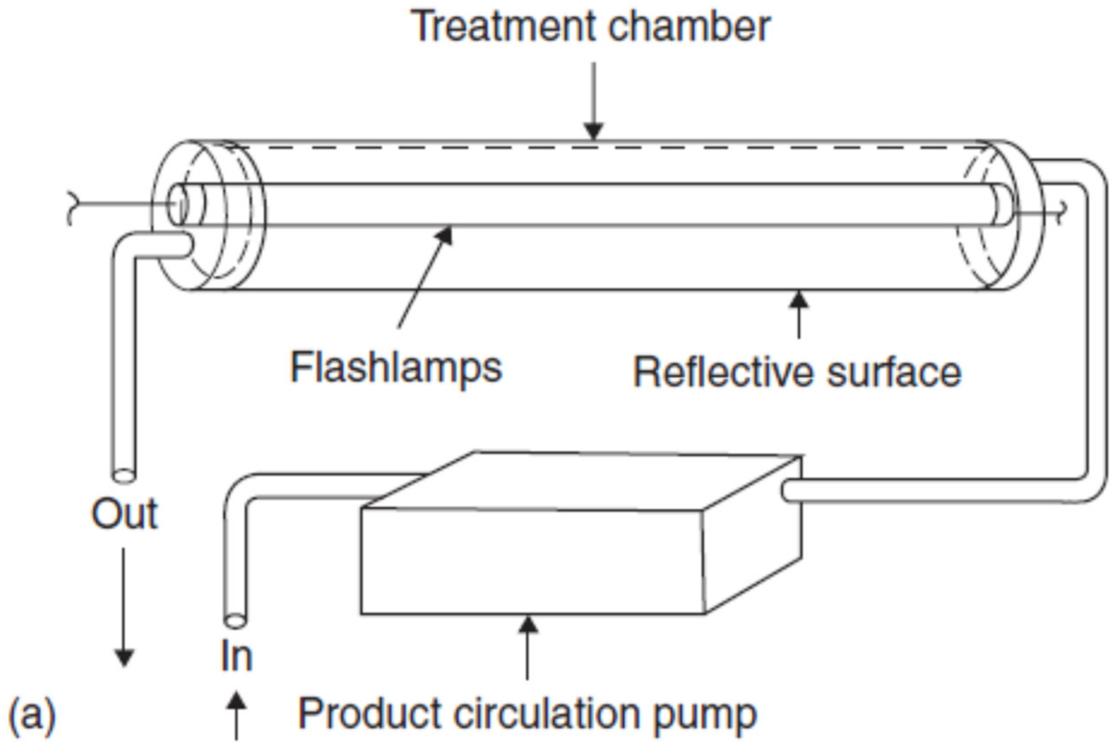


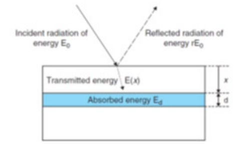
Figure 11.3 A flowsheet of a general pulsed light system.

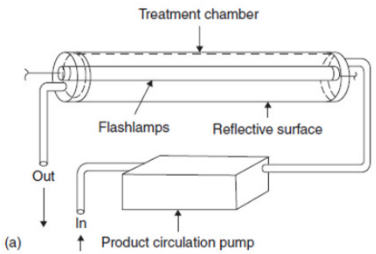


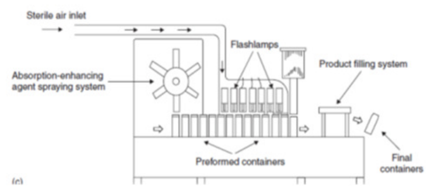


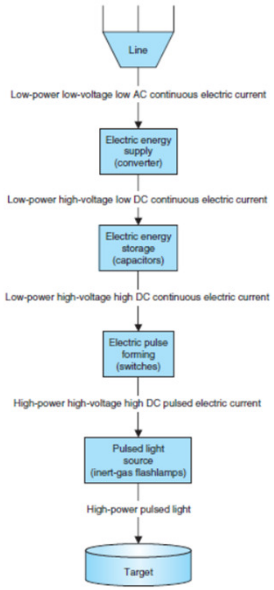

Line
Low-power low-voltage low AC continuous electric current
Electric energy supply (converter)
Low-power high-voltage low DC continuous electric current
Electric energy storage (capacitors)
Low-power high-voltage high DC continuous electric current
Electric pulse forming (switches)
High-power high-voltage high DC pulsed electric current
Pulsed light source (inert-gas flashlamps)
High-power pulsed light
Target

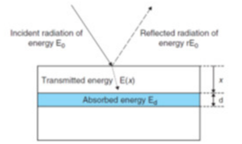

Treatment chamber
Flashlamps
Reflective surface
Out
In
Product circulation pump
(a)

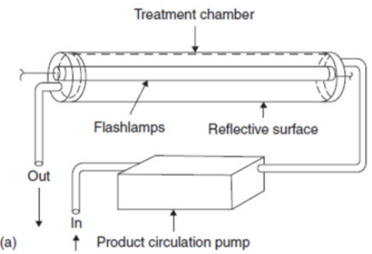

Incident radiation of energy E_0
Reflected radiation of energy rE_0
Transmitted energy $E(x)$
Absorbed energy E_d
x
d


Treatment chamber
Flashlamps
Reflective surface
Out
In
Product circulation pump
(a)

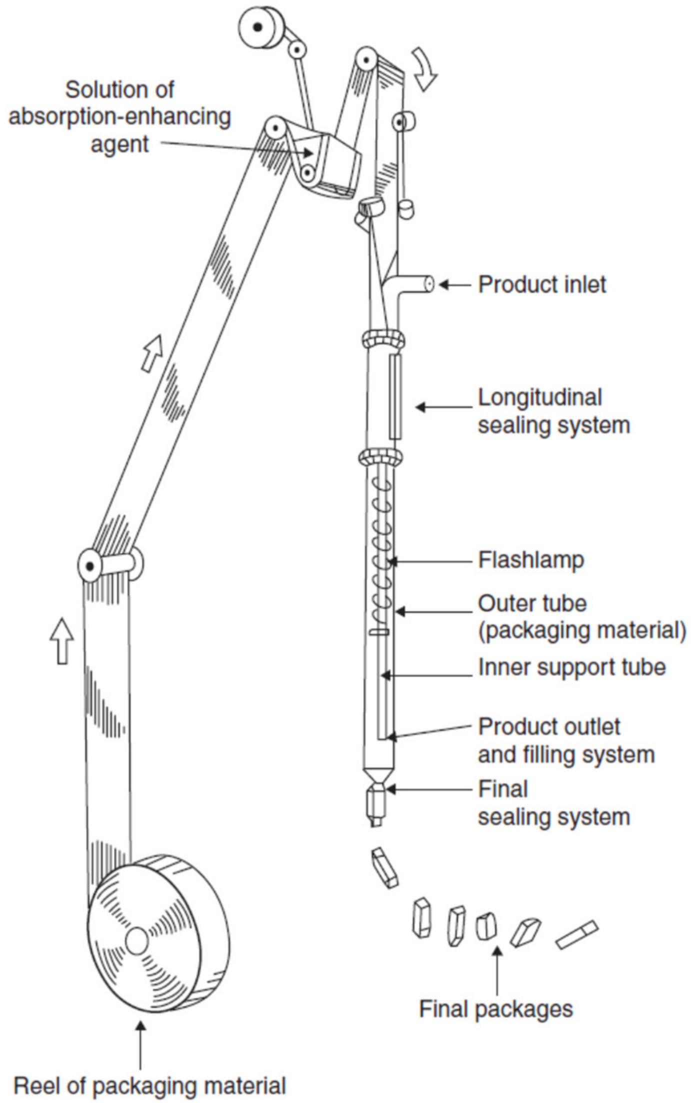

Sterile air inlet
Flashlamps
Product filling system
Absorption-enhancing agent spraying system
Preformed containers
Final containers


Line
Low-power low-voltage low AC continuous electric current
Electric energy supply (converter)
Low-power high-voltage low DC continuous electric current
Electric energy storage (capacitors)
Low-power high-voltage high DC continuous electric current
Electric pulse forming (switches)
High-power high-voltage high DC pulsed electric current
Pulsed light source (inert-gas flashlamps)
High-power pulsed light
Target

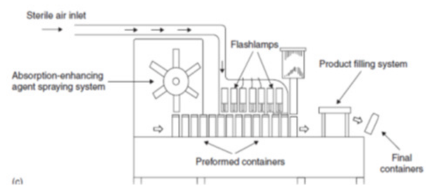

Incident radiation of energy E_0
Reflected radiation of energy rE_0
Transmitted energy $E(x)$
Absorbed energy E_d
x
d


Treatment chamber
Flashlamps
Reflective surface
Out
In
Product circulation pump

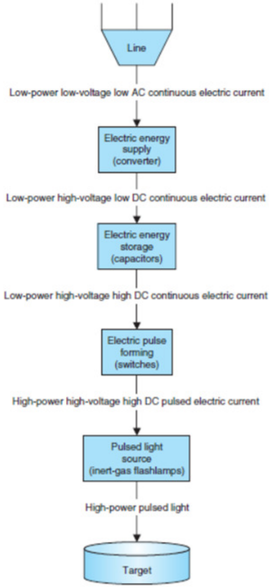
(a)

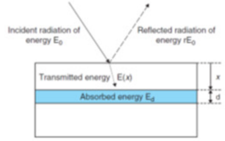

Solution of absorption-enhancing agent
Product inlet
Longitudinal sealing system
Flashlamp
Outer tube (packaging material)
Inner support tube
Product outlet and filling system
Final sealing system
Final packages
Reel of packaging material

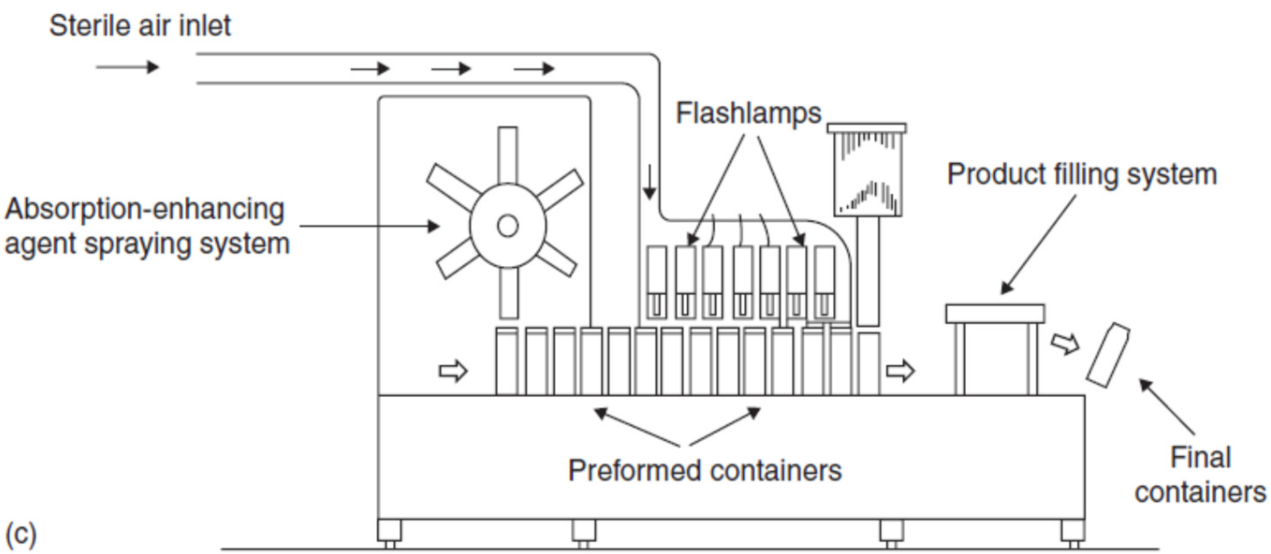
(b)


Sterile air inlet
Flashlamps
Product filling system
Absorption-enhancing agent spraying system
Preformed containers
Final containers

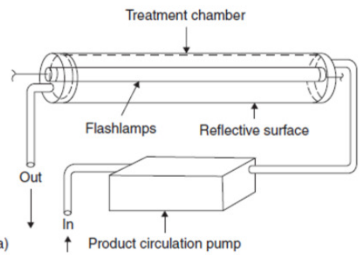
(c)


Line
Low-power low-voltage low AC continuous electric current
Electric energy supply (converter)
Low-power high-voltage low DC continuous electric current
Electric energy storage (capacitors)
Low-power high-voltage high DC continuous electric current
Electric pulse forming (switches)
High-power high-voltage high DC pulsed electric current
Pulsed light source (inert-gas flashlamps)
High-power pulsed light
Target

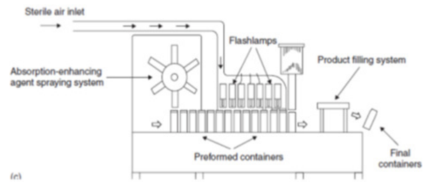

Incident radiation of energy E_0
Reflected radiation of energy rE_0
Transmitted energy $E(x)$
Absorbed energy E_d
x
d

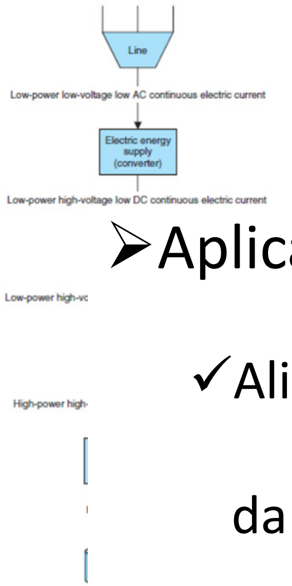

Sterile air inlet
Flashlamps
Product filling system
Absorption-enhancing agent spraying system
Preformed containers
Final containers

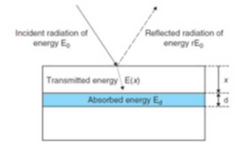
(c)


Treatment chamber
Flashlamps
Reflective surface
Out
In
Product circulation pump

(a)


Sterile air inlet
Flashlamps
Product filling system
Absorption-enhancing agent spraying system
Preformed containers
Final containers



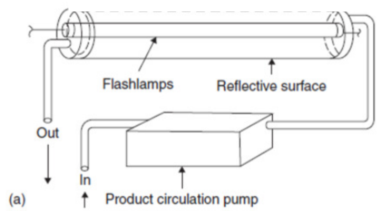


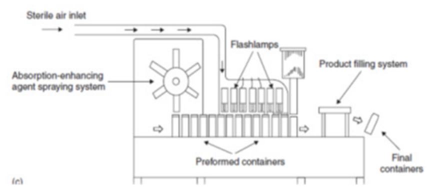
Processamento por Pulso de Luz

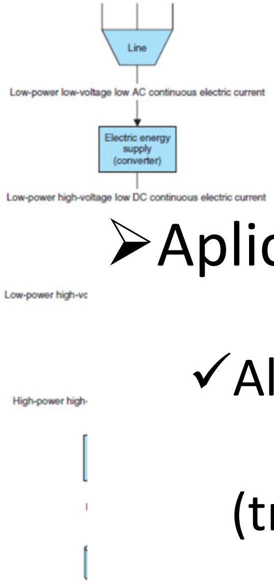
➢ Aplicações:

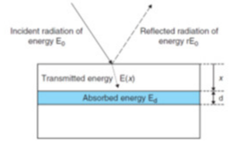
✓ Alimentos sólidos não embalados para descontaminação ou esterilização da superfície (pré-tratamento)

✓ Alimentos sólidos embalados (embalagens compatíveis com a luz pulsada) para descontaminação ou esterilização da superfície (tratamento final)







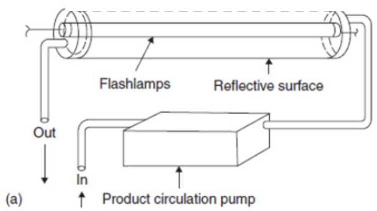


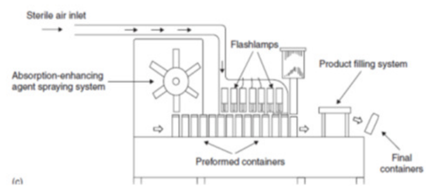
Processamento por Pulso de Luz

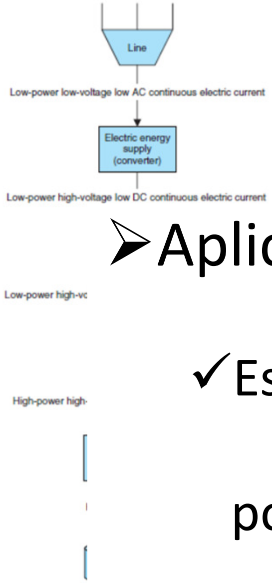
➢Aplicações:

✓Alimentos líquidos escoando em câmaras de tratamento (transparência)

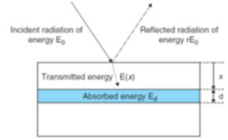
✓Alimentos líquidos embalados (embalagens compatíveis com a luz pulsada)







Processamento por Pulso de Luz



➢ Aplicações:

✓ Esterilização de embalagens para produtos alimentícios (PE, PP, polibutileno, EVA, náilon, aclar, EVOH)

✓ Embalagens não compatíveis: vidro, poliestireno e PET

✓ Evitar presença de tinta e impressões nas embalagens antes do tratamento com luz pulsada