SOLIENS
VIRTUAL ACADEMY

1.2.1

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Efeito Fotovoltaico

O efeito fotovoltaico é a criação de tensão ou corrente elétrica em um material após a exposição à luz e é uma propriedade física e química.

O efeito fotovoltaico está intimamente relacionado com o efeito fotoelétrico. Em ambos os casos, a luz é absorvida, causando a excitação de um elétron ou outro portador de carga para um estado de energia mais alta. Um potencial elétrico (ou tensão) é produzido pela separação de cargas, e a luz tem que ter uma energia suficiente para superar a barreira de potencial para excitação.

A primeira demonstração do efeito fotovoltaico em 1839 usou uma célula eletroquímica, mas a forma mais familiar do efeito fotovoltaico nos tempos modernos, porém, é em dispositivos de estado sólido, principalmente em fotodiodos.

Quando a luz solar ou outra luz suficientemente energética incide sobre o fotodiodo, os elétrons presentes na camada de valência absorvem energia e, sendo excitados, saltam para a banda de condução e tornam-se livres.

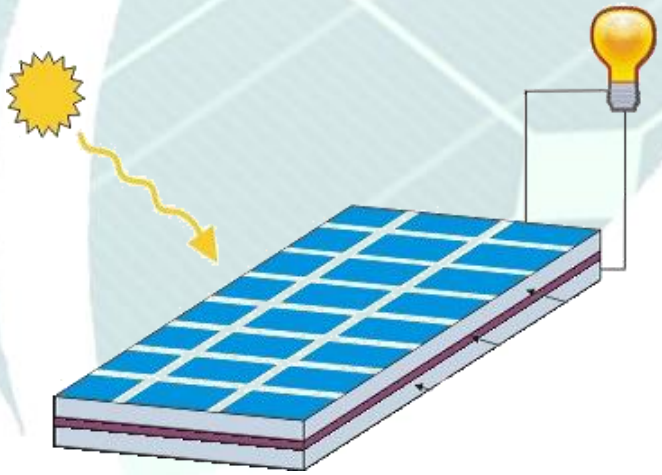

Figura 1 – Célula Fotovoltaica - Fonte: solarbrasil (www.solarbrasil.com.br)

Estes elétrons excitados difundem-se, e alguns alcançam a junção retificadora (geralmente uma junção p-n) onde são acelerados em um material diferente por um potencial incorporado (potencial de Galvani). Isso gera uma força eletromotriz, e assim parte da energia luminosa é convertida em energia elétrica.

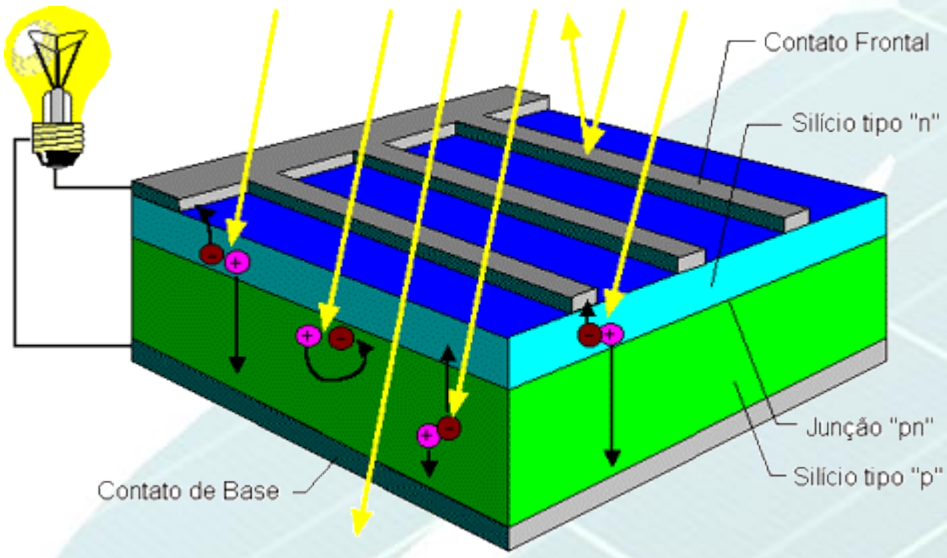

Figura 2 – Junção PN - Fonte: Cresesb (www.cresesb.cepel.br)

O efeito fotovoltaico foi observado pela primeira vez pelo físico francês **AE Becquerel** em 1839. Ele explicou sua descoberta em **Les Comptes Rendus de l'Academie des Sciences**, "a produção de uma corrente elétrica quando duas placas de platina ou ouro imerso em um ácido, ou solução alcalina são expostos de forma desigual à radiação solar".

Além da excitação direta de elétrons livres, um efeito fotovoltaico também pode surgir simplesmente devido ao aquecimento causado pela absorção da luz. O aquecimento leva a um aumento da temperatura, que é acompanhado por gradientes de temperatura.

Na maioria das aplicações fotovoltaicas a radiação é a luz solar, e os dispositivos são chamados de células solares. No caso de uma célula solar de junção p-n, a iluminação do material cria uma corrente elétrica como elétrons

excitados e os furos remanescentes são varridos em direções diferentes pelo campo elétrico interno da região de depleção.

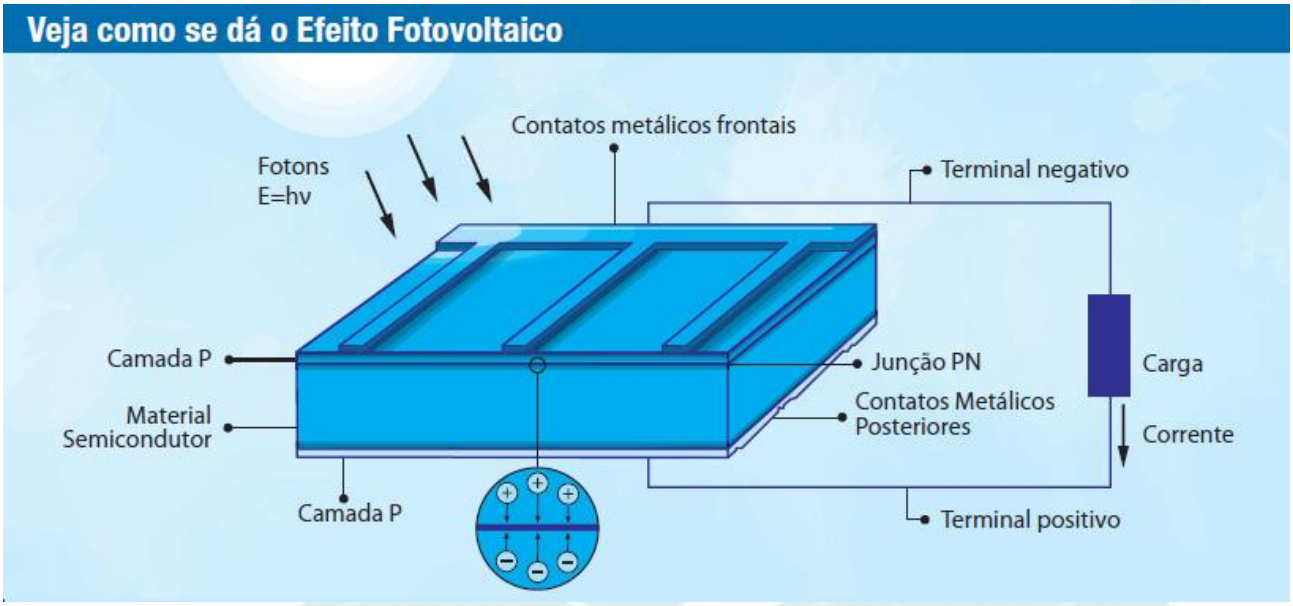

Figura 3 – Efeito Fotovoltaico – Fonte: Energia Tecsolar (www.energiatecsolar.com.br)

Num semicondutor exposto à luz, um fóton de energia arranca um elétron, criando ao mesmo tempo uma lacuna ou buraco no átomo excitado. Normalmente, o elétron encontra rapidamente outra lacuna para voltar a preenchê-lo, e a energia proporcionada pelo fóton, por tanto, dissipa-se em forma de calor.

O princípio de uma célula fotovoltaica é obrigar os elétrons e as lacunas a avançar para o lado oposto do material em lugar de simplesmente recombinar-se nele: assim, produzir-se-á uma diferença de potencial e, portanto, tensão entre as duas partes do material, como ocorre numa pilha.

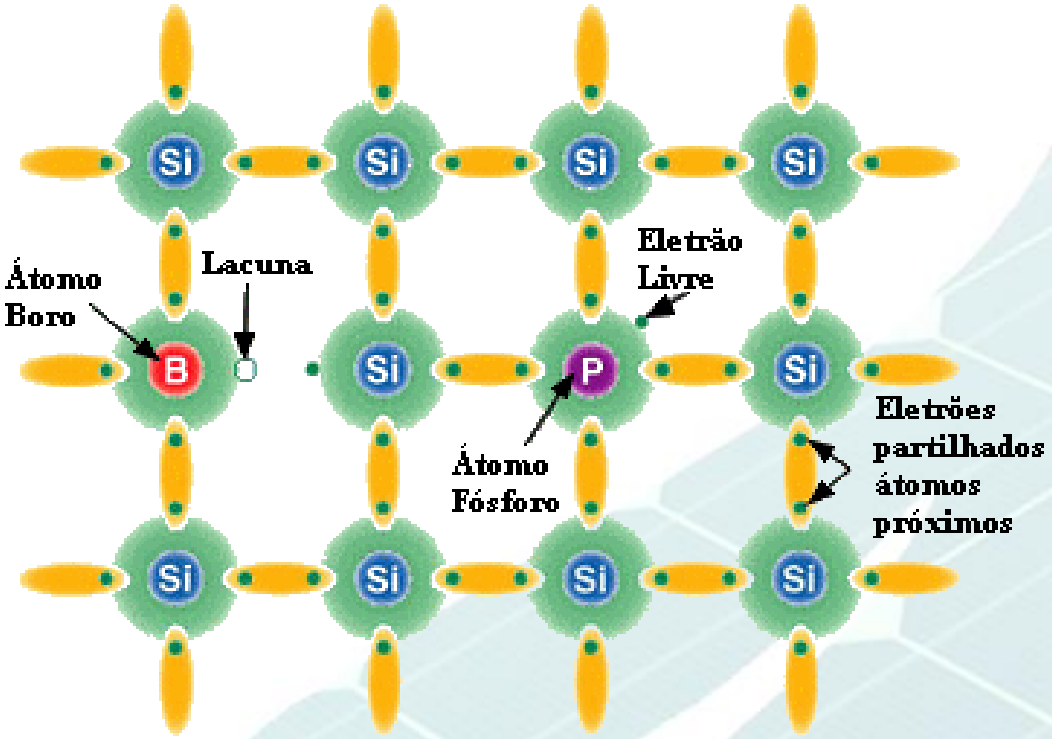

Figura 4 – Lacunas e Elétrons – Fonte: Electronica-PT (www.electronica-pt.com)

Para isso, cria-se um campo elétrico permanente, através de uma união PN, entre duas capas dopadas respectivamente, P e N. Nas células de silício, que são majoritariamente utilizadas, se encontram por tanto:

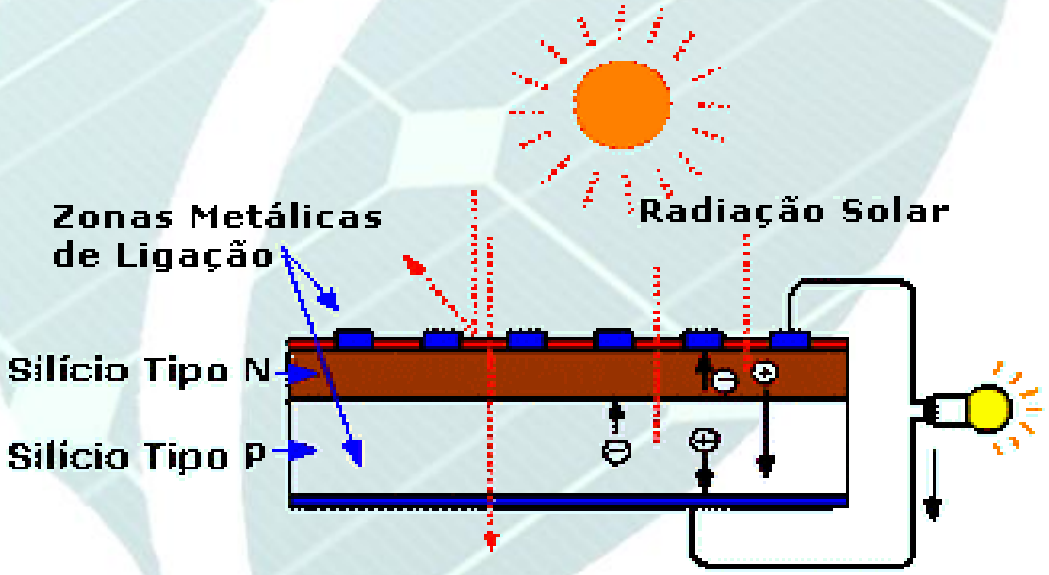

Figura 5 – Ligação PN – Fonte: Electronica-PT (www.electronica-pt.com)

A capa superior da célula, se compõe de silício dopado de tipo N. Nesta capa, há um número de elétrons livres maior que numa capa de silício puro, daí o nome de dopagem N, negativo. O material permanece eletricamente neutro, já que tanto os átomos de silício como os do material dopante são neutros: mas a rede cristalina tem globalmente uma maior presença de elétrons que numa rede de silício puro.

A capa inferior da célula, se compõe de silício dopado de tipo P. Esta capa tem, portanto, uma quantidade média de elétrons livres menor que uma capa de silício puro. Os elétrons estão unidos à rede cristalina que, em consequência, é eletricamente neutra mas apresenta lacunas, positivas (P). A condução elétrica está assegurada por estes portadores de carga, que se deslocam por todo o material.

No momento da criação da união PN, os elétrons livres de capa N entram instantaneamente na capa P e se recombinam com as lacunas na região P. Existirá assim durante toda a vida da união, uma carga positiva na região N ao longo da união (porque faltam elétrons) e uma carga negativa na região em P ao longo da união (porque as lacunas têm desaparecido); o conjunto forma a «Zona de Carga Espacial» (ZCE) e existe um campo elétrico entre as duas, de N para P. Este campo elétrico faz da ZCE um diodo, que só permite o fluxo de corrente numa direção: os elétrons podem mover da região P ao N, mas não na direção oposta e pelo contrário as lacunas não passam mais que de N para P.

Em funcionamento, quando um fóton expulsa um elétron da matriz, criando um elétron livre e uma lacuna, sobre o efeito deste campo elétrico, cada um vai em direção oposta: os elétrons acumulam-se na região N (para converter-se em polo negativo), enquanto as lacunas acumulam-se na região dopada P (que se converte no polo positivo).

Este fenómeno é mais eficaz na zona de carga espacial, onde quase não há portadores de carga (elétrons ou lacunas), já que são anulados, ou na redondeza imediata à ZCE: quando um fóton cria um par elétron-lacuna, separaram-se e é improvável que encontrem a seu oposto, mas se a criação tem lugar num lugar mais afastado da união, o elétron (convertido em lacuna) mantém uma grande oportunidade de recombinar-se antes de chegar à zona N.

Mas a ZCE é necessariamente muito fina, de modo que não é útil dar uma grande espessura à célula. Efetivamente, a espessura da capa N é muito pequena, já que esta capa só é necessária basicamente para criar a ZCE que faz funcionar a célula. Em mudança, a espessura de capa P é maior: depende de um compromisso entre a necessidade de minimizar as recombinações elétron-lacuna, e pelo contrário permitir a captação do maior número de fótons possível, para o que se requer mínima espessura.

Em resumo, uma célula fotovoltaica é o equivalente de um gerador de energia à que se acrescentou um diodo. Para conseguir uma célula solar prática, também é preciso acrescentar contatos elétricos (que permitam extrair a energia gerada), uma capa que proteja a célula mas deixe passar a luz, uma capa anti-reflexo para garantir a correta absorção dos fótons, e outros elementos que aumentem a eficiência do mesmo.

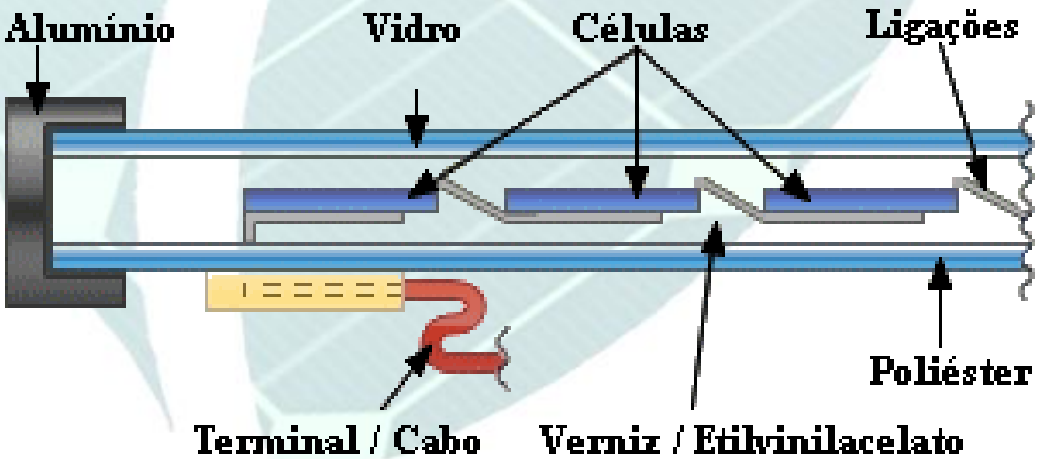

Figura 6 – Constituição interna de uma célula fotovoltaica - Fonte: Electronica-PT (www.electronica-pt.com)

Um conjunto de células fotovoltaicas constitui um painel fotovoltaico, também conhecido como módulo fotovoltaico.

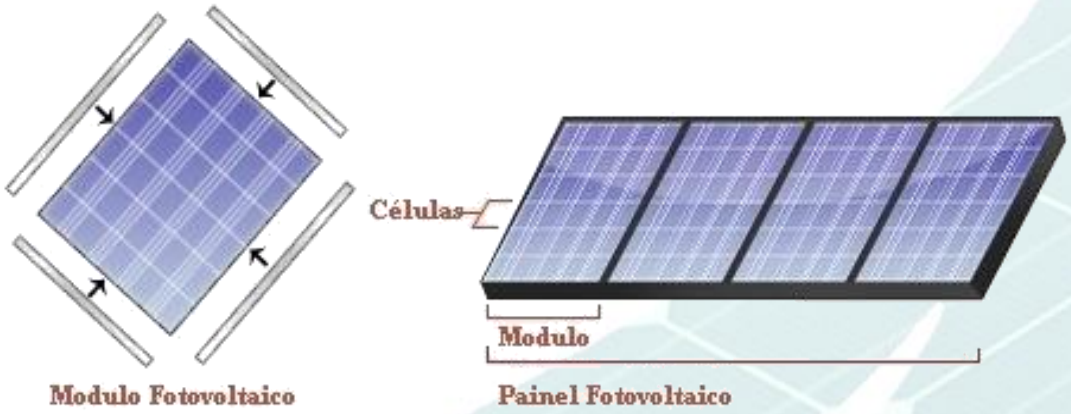

Figura 7 – Conjunto de células formando um painel - Fonte: Electronica-PT (www.electronica-pt.com)

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