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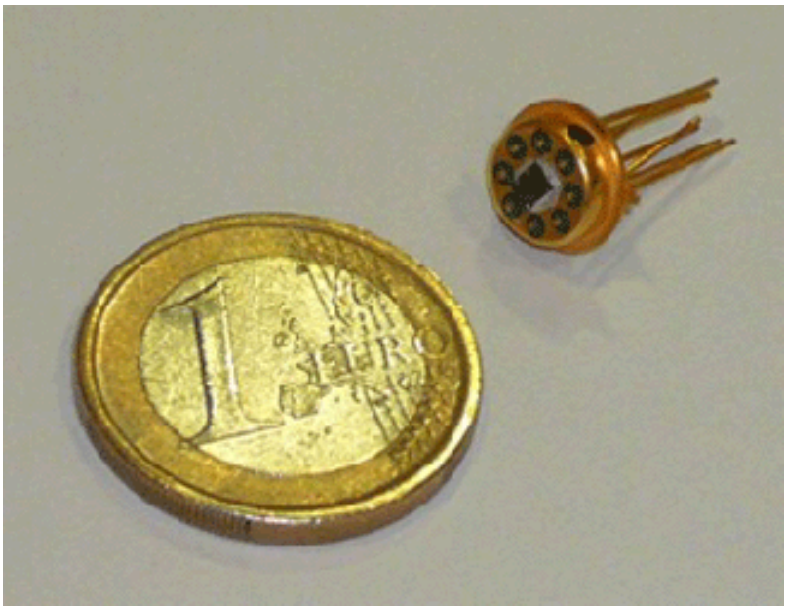
Silicon nanocrystal-based light-sources



The microelectronics technology allows to design devices able to manipulate the light and to turn it in electrical signals. But it is limited because the use of silicon, a material unsuitable to make miniaturized light emitting devices. Researchers of the Microelectronics National Center have improved this type of emitters using silicon nanocrystals.

Electronics is and has been the key element of the social technological development for the last decades. The microelectronic technology, through steady improvements in miniaturization combined with capability of mass production of its components, has granted a whole set of everyday solutions. However, the scientific and industrial community is aware that there are physical limitations that will end up cutting down the improving trend. Because of that, the research effort put on alternative microelectronic materials and new communication technologies has increased drastically for the last years. Optical devices, the most promising alternative, are nowadays omnipresent in the communications field. By using the present microelectronic technology it is possible to design and fabricate devices capable of manipulating light and transmuting it into electrical signals.

Sadly the key element that has granted the electronics technological development, silicon, has not ended up an adequate material for light emission devices. The use of alternative materials and alloys, like aluminum, indium or phosphorus has allowed the development of a wide variety of solid-state light-sources which, on the other hand are not fully compatible with traditional silicon electronic circuits.

Luckily, in the early 90s it was proved that silicon nanocristals, crystalline silicon structures just a few nanometers big (picture1), are an excellent alternative. The drastical reduction of the crystal size emphasizes quantum effects which completely change the material properties. Since then, several silicon microelectronics compatible techniques have been improved in order to obtain silicon nanocrystals.

Picture 1.

In this work, light emitting devices based on silicon nanocrystals have been developed. The nanocrystals, embedded in silicon oxide layers (picture 2), are obtained by plasma enhanced chemical vapor deposition (PECVD) rather than the usual ion implantation silicon oxide enrichment techniques. It has been proved that the origin of the generated light relies on a radiative recombination process inside the nanocrystals. The emission spectrum, centered at 800 nm, is broad wide and covers mainly the visible-red region. Results show, moreover, that just a few volts are enough to control the electric current-charge injection. Finally, it has been studied the relation between the stoichiometry of the oxide, directly related to the amount of silicon excess and subsequently the presence of nanocrystals, with the electrical permittivity, which determines the response of a material to external electrical fields.

These results encourage expecting a complete electro-optical device capable of manipulating light-signals generated from electrical stimulus and transform them back into electrical signals.

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