Popular Science

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With the current digitisation and increasing living standards across the globe, the global electricity consumption is rapidly increasing. It is to no surprise that scientists from all over the world are constantly searching for more efficient energy solutions through explorations of new materials. For the last two decades, the material that holds the crown for the future saviour of the world is a perovskite crystal.

It is of course no ordinary crystal like that you find on a fancy engagement ring or in a box of salt. It is a crystal prepared in a lab where scientists are like chefs that can cook up countless different perovskite crystals with great amount of freedom from various elements of the periodic table. This almost magical crystal has excellent properties for solar cells, LED lamps, electronics and detectors of visible light or X-rays (which you take when you break a leg). The wide range of applications where perovkites are predicted to succeed even on the industrial market is given by the malleable character of the possible element composition and its semiconducting nature. But what does it mean to be a semiconductor?

It simply means that the material only conducts electricity sometimes and in a controllable manner. You can imagine the electronic structure of a semiconductor as two shelves above each other. The bottom shelf is full of billiard balls while the top is completely empty. The billiard balls in the bottom shelf sit so tightly that there can be no motion. Imagine now that the billiard balls are electrons and that the only way to move an electron from the bottom to the top shelf is by giving it an extra energy, let's say in the form of light. When a semiconductor receives this extra energy, its electrons jump from the bottom to the top shelf where the electrons can move freely and conduct electricity. After a while the electrons can fall back down to the bottom shelf but at the same time they need to give off the extra energy that got them up in the first place. One way to get rid off this energy is to covert it back to the form of light which has the same energy as, approximately, the gap between these two shelves. The process of a semiconductor emitting light is called photoluminescence. The studies of the light emitted by the semiconductor can therefore reveal information about the material's electronic structure.

Now coming back to perovskites and their outstanding properties, even more attractive characteristics are seen for small perovskite rods which are 500 times thinner than human hair. We call these rods nanowires. To make the perovskite nanowires, we can use a template covered with many pores and let the nanowires grow in the pores. Given the unstable nature of perovskites, the template can act as a physical protection of the crystals as well. This work focuses exactly on these thin nanowires of a particular perovskite, cesium lead bromide ($CsPbBr_3$), grown inside different templates with varying pore sizes. The electronic structure of the samples with different nanowire diameters was studied by shining a laser on the sample and analysing the photoluminescence light coming out of the sample. Our photoluminescence study clarifies the dependence of the electronic structure of the perovskite crystal on the diameter size and investigates an ideal pore size for the application of the material in a future detector for X-rays. So who knows, maybe one day you will be leaving the hospital with an X-ray image made with a perovkite-based detector!