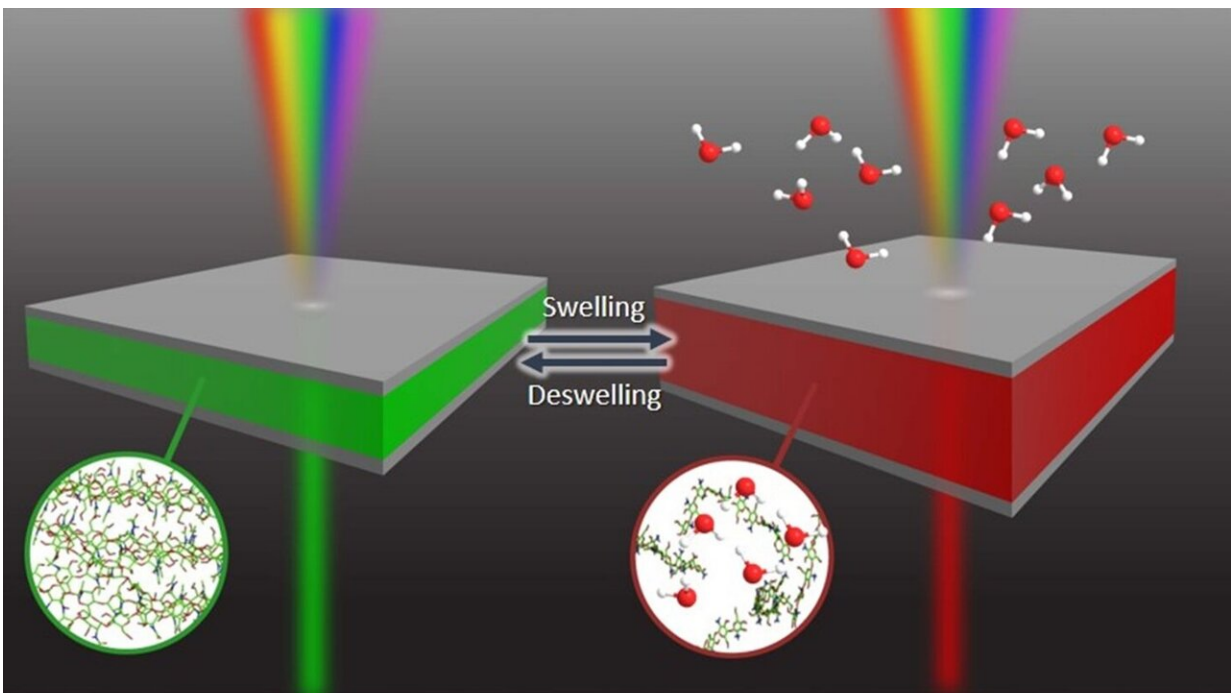


Smart windows that self-illuminate on rainy days

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Metal-hydrogel-metal filter structure that repeats expansion and contraction as moisture level changes around it.

Credit: Pohang University of Science & Technology (POSTECH)

Smart windows that automatically change colors depending on the intensity of sunlight are gaining attention as they can reduce energy bills by blocking the sun's visible rays during summer. But what about windows that change colors depending on the humidity outside during

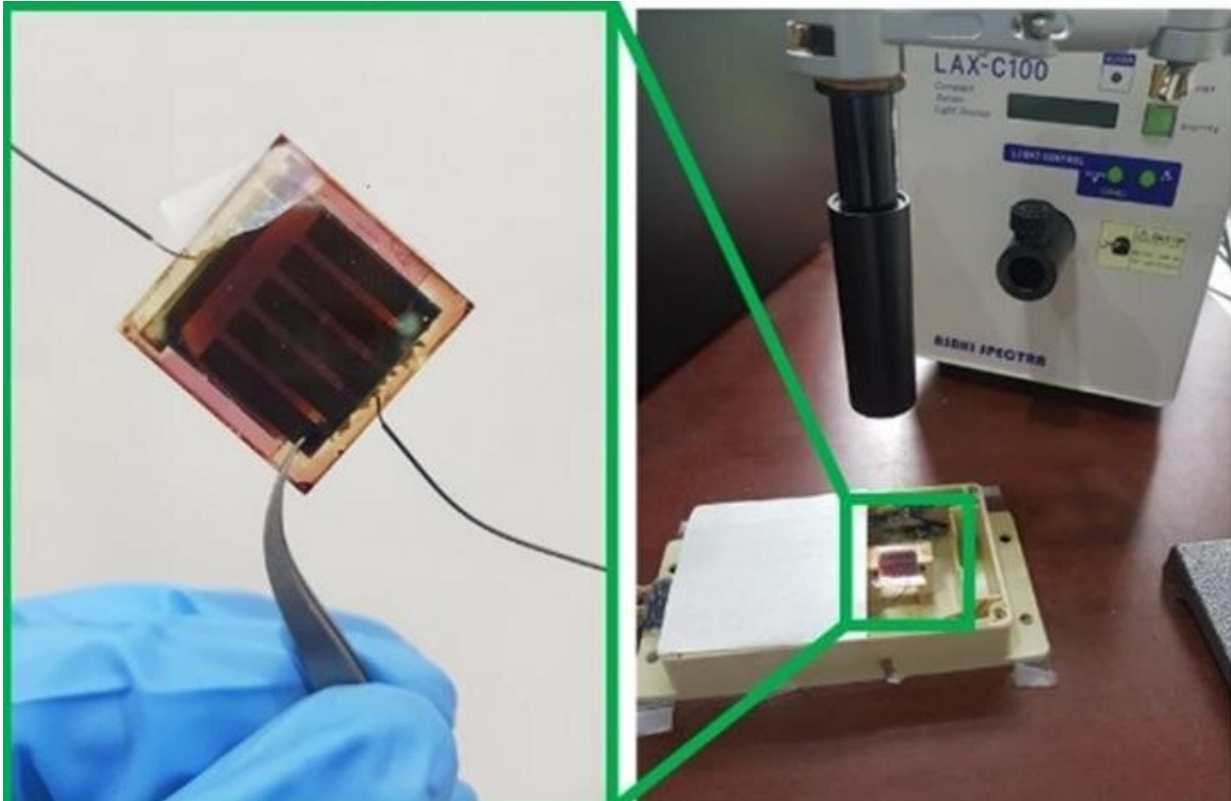
the monsoon season or on hot days of summer?

Recently, a Korean research team has developed the source technology for smart windows that change colors according to the amount of moisture, without needing electricity.

The joint research team comprised of Professor Junsuk Rho of the departments of mechanical and chemical engineering, Jaehyuck Jang and Aizhan Ismukhanova of the chemical engineering department at POSTECH, and Professor Inkyu Park of KAIST's department of mechanical engineering. Together, they successfully developed a variable color filter using a metal-hydrogel-metal resonator structure using a chitosan-based hydrogel and combined it with [solar cells](#) to make a self-powering humidity sensor. These research findings were published as a cover story in the latest edition of *Advanced Optical Materials*, a journal specializing in nanoscience and optics.

Sensors utilizing [light](#) are already widely used in our daily lives in measuring the ECG, air quality, or distance, for example. The basic principle is to use light to detect changes in the surroundings and to convert them into digital signals.

Fabri-Pero interference is one of the resonance phenomena that can be applied in optical [sensors](#) and can be materialized in the form of multilayer thin films of metal-dielectric-metal. It is known that the resonance wavelength of transmitted light can be controlled according to the thickness and refractive index of the dielectric layer. However, the existing metal-dielectric-metal resonators have a major disadvantage in not being able to control the wavelengths of transmitted light once they are manufactured, making it difficult to use them in variable sensors.



Humidity sensor combining variable filter and solar cells. Credit: Junsuk Rho (POSTECH)

The research team found that when the chitosan hydrogel is made into the metal-hydrogel-metal structure, the resonance wavelength of light transmitted changes in real time depending on the humidity of the environment. This is because the chitosan hydrogel repeats expansion and contraction as the humidity changes around it.

Using this mechanism, the team developed a [humidity sensor](#) that can convert light's energy into electricity by combining a solar battery with a water variable wavelength filter made of a metal-hydrogel-metal structured metamaterial that changes resonance wavelength depending on the external humidity.

The design principle is to overlap the filter's resonance wavelength with the [wavelength](#) where the absorption of the solar cells changes rapidly. This filter is designed to change the amount of light absorption of solar cells depending on the amount of moisture, and to lead to electric changes that ultimately detect the surrounding humidity.

Unlike conventional optical humidity sensors, these newly developed ones work regardless of the type of light, whether it be natural, LED or indoor. Also, not only does it function without external power, but it can also predict humidity according to the filter's color.

Professor Junsuk Rho who led the research commented, "This technology is a sensing technology that can be used in places like nuclear power reactors where people and electricity cannot reach." He added, "It will create even greater synergy if combined with IoT technology such as humidity sensors that activate or smart windows that change colors according to the level of external [humidity](#)."

More information: Jaehyuck Jang et al, Self-Powered Humidity Sensor Using Chitosan-Based Plasmonic Metal–Hydrogel–Metal Filters, *Advanced Optical Materials* (2020). [DOI: 10.1002/adom.201901932](https://doi.org/10.1002/adom.201901932)

Provided by Pohang University of Science & Technology (POSTECH)

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