Dressing a metal in various colors

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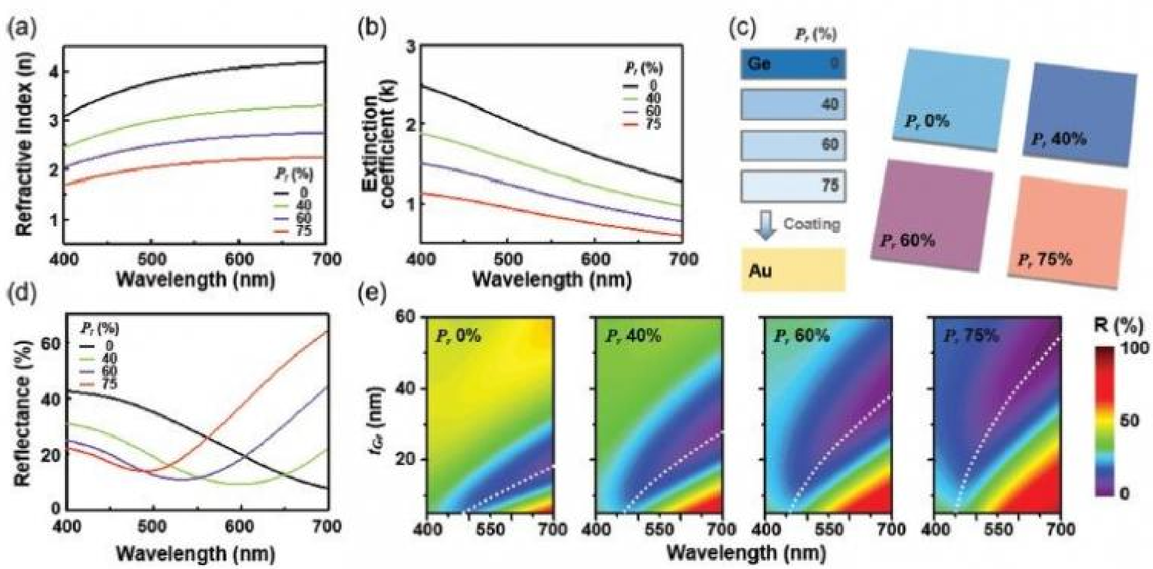

Fig. 1 (a) Calculated refractive index and (b) extinction coefficient spectra of Ge with four different porosities (Pr) (0%, 40%, 60% and 75%) as a function of wavelength. (c) Left, schematic view of proposed thin-film coatings with different Pr (i.e. 0%, 40%, 60% and 75%). Right, thin-film structures represented by calculated colors with different Pr (i.e. 0%, 40%, 60% and 75%) at the same thickness of 20 nm. (d) Calculated reflectance spectra of ultra-thin optical coatings (Pr-Ge/Au) with different Pr. (e) Contour plot of reflectance variation for Pr-Ge/Au with four different Pr as a function of Ge thickness (tGe), and of wavelength. White dashed lines in each contour plot indicate variations in the resonance dip. (f) Color representations from calculated reflectance in (e). Credit: Daegu Gyeongbuk Institute of Science and Technology (DGIST)

DGIST announced that Professor Kyung-in Jang's research team succeeded in developing a technology that can control various color changes by coating several nanometers of semiconducting materials on a metal substrate through joint research with a research team led by professor Young-min Song of GIST.

Professor Kyung-in Jang's research team has succeeded in changing the unique color of metals such as gold, silver, aluminum, etc. with strong thin-film interference effect caused by light reflected on the surface of the metals and semiconducting materials by coating an ultra-thin layer of several nanometers (1 nanometer is one one-billionth of a meter) of semiconductor substances on the metals.

There have been previous studies that show that color changes depend on the thickness of ultra-thin film of semiconducting materials such as germanium coated on a gold substrate; however, there have been some difficulties due to the rapid change of colors and with color darkening techniques.

The research team coated a thin germanium film of 5 to 25 nanometers on a gold substrate by utilizing oblique angle deposition (OAD). As a result, they succeeded in producing various colors such as yellow, orange, blue, and purple at will according to the thickness and deposition angle of the germanium coating.

It was confirmed that the range of color expression expanded and the purity of color was enhanced by making a porous structure with a large number of fine holes that have a significant presence in the germanium layer. By applying the oblique angle deposition method, the variation and purity of colors were also varied according to the thickness change of the germanium film in nanometers.

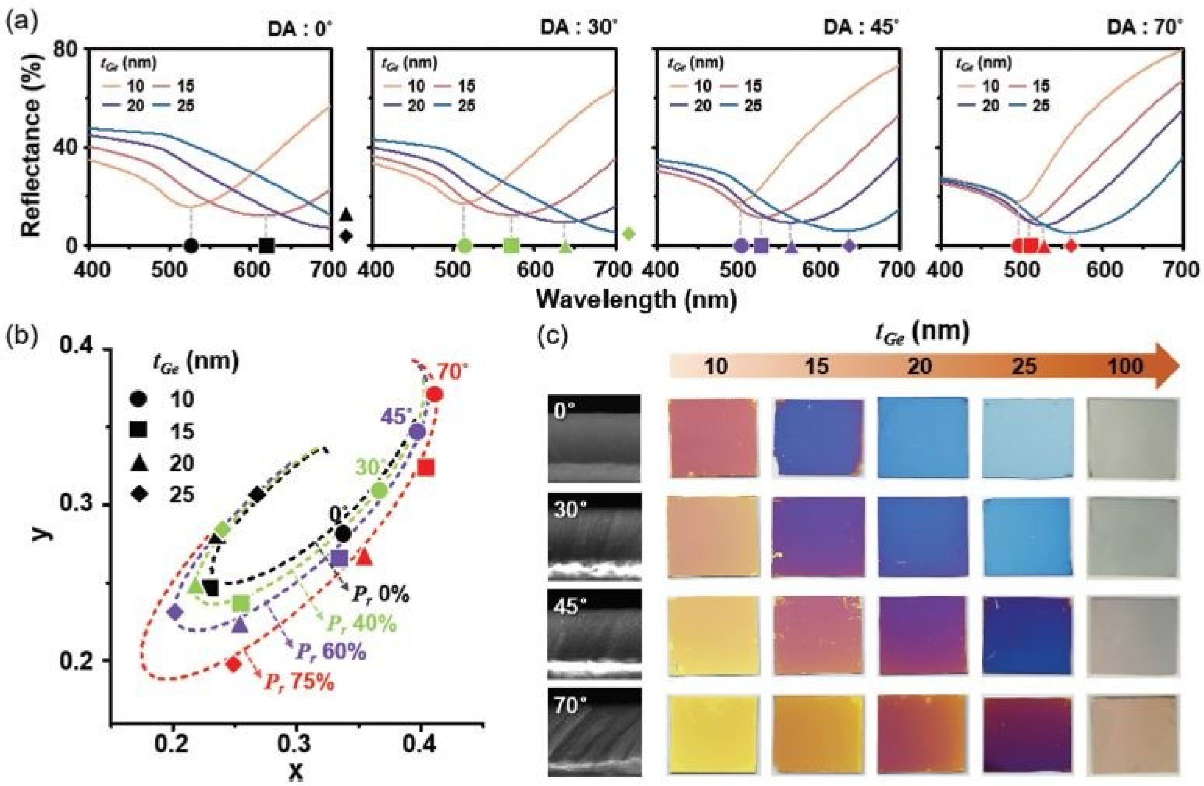

Figure 2. (a) Measured reflectance spectra in each of deposition angles (DAs) (i.e., 0°, 30°, 45° and 70°) with different Ge thicknesses (i.e., 10 nm, 15 nm, 20 nm and 25 nm). (b) Chromatic values in the CIE coordinate from measured reflectance as shown in (a). Chromatic values for ultra-thin films with four different Pr (i.e., 0%, 40%, 60% and 75%) are also shown by dash lines for comparison. (c) Pictures of the fabricated samples of different DAs (i.e., 0°, 30°, 45° and 70°) with different Ge thicknesses (i.e., 10 nm, 15 nm, 20 nm, 25 nm and 100 nm). Left, gray-scale figures show scanning microscopy images corresponding to the samples with Ge thickness of 200 nm to better show the morphology. Credit: Daegu Gyeongbuk Institute of Science and Technology (DGIST)

Professor Kyung-in Jang from DGIST said, "The result of this research is the development of a simple method of applying various colors to existing electronic devices and currently we have succeeded in expressing single colors, but we may also be able to coat patterns such as symbols and pictures. In the future, I think it can be used in coating visual designs on flexible devices such as solar cells, wearable devices, and displays that are used for various purposes including building exterior walls. It can also be applied in camouflage by coating things with the same pattern or color as the surrounding objects."

Meanwhile, this research outcome was published on December 9, 2016 in the online edition of *Nanoscale*, an international academic journal in the field of nanotechnology, and the research was supported by the basic research project (collective research) of the National Research Foundation of Korea.

More information: Young Jin Yoo et al. Ultra-thin films with highly absorbent porous media fine-tunable for coloration and enhanced color purity, *Nanoscale* (2017). DOI: 10.1039/C6NR08475C

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