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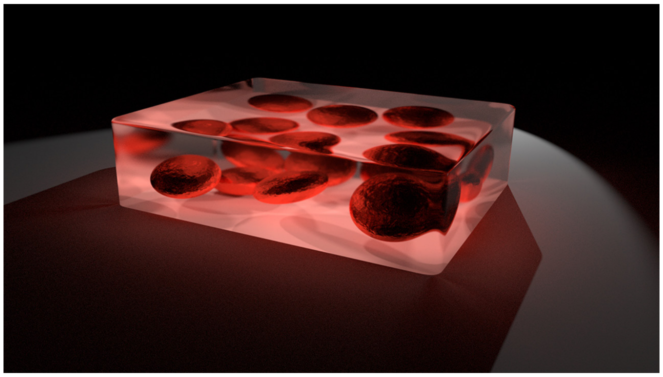
Asymmetric hysteresis in vanadium dioxide insulator-to-metal transition is a function of ellipsoidal inclusions whose shape is temperature dependent.



Vanadium dioxide made headlines in 2017 when research demonstrated that it conducts electricity without heat. Its physical properties, including being that of an insulator below 68 degrees Celsius and a metal above, have made it an excellent candidate for thermal applications, including infrared sensing, cameras, and the prosaic task of blocking infrared radiation as a coating on glass. While scrutinized about the material's behavior during this insulator-to-metal transition – observing that it has an asymmetric hysteresis — there are still open questions regarding the process.

Voloshenko et al.'s work confirms a percolative transition in which the metallic inclusions within a vanadium dioxide thin film change shape during heating and cooling. This allows them to characterize the temperature-dependent spectral dielectric functions as the material transitions between an insulator and a metal.

The authors used spectroscopic ellipsometry to monitor the change in index of refraction and extinction coefficient of a thin film of vanadium dioxide over a range of wavelengths and incidence angles as the film was heated and cooled. The transition was more abrupt during cooling than heating. A sudden increase in reflectance near the critical temperature supported a percolation transition.

They also modified a standard approximation called the Bruggeman effective medium approximation by assuming the metallic inclusions were ellipsoidal, rather than spherical, and were of different shapes during heating and cooling events. The metallic inclusions flattened at high temperatures and developed distinct shapes. Their model produced values in close agreement to their measurements, offering an explanation for the asymmetric hysteresis loop observed during the insulator-to-metal transition.

Source: "Microscopic nature of the asymmetric hysteresis in the insulator-metal transition of VO_2 revealed by spectroscopic ellipsometry," by Ievgen Voloshenko, Florian Kuhl, Bruno Gompf, Angelika Polity, Gabriel Schnoering, Audrey Berrier, and Martin Dressel, *Applied Physics Letters* (2018). The article can be accessed at https://doi.org/10.1063/1.5055296.