Quantum nanostructures of correlated metal oxides

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NANOSTRUCTURES of functional materials provide an experimental platform to study novel physical phenomena when the characteristic device size reaches intrinsic length scales, such as the inelastic scattering length or the Fermi wavelength [1]. Nanostructures of mean-field systems, especially semiconductors, with confined electron systems have been studied for decades, leading to widespread technological applications. However, studies of correlated systems, such as complex oxide materials, are mainly presented in 2D, especially at interfaces. Confinement effects in fewer dimensions, i.e., 0D, have been only marginally studied due to the challenges associated with the fabrication of 0D objects from 3D oxide materials with low defect density.

In this study, we present two different approaches (top-down and bottom-up) for fabricating quantum nanostructures of correlated metal oxides. We illustrate the top-down fabrication and exploration of arrays of nanodots of $SrRuO_3$ with dot sizes between 500 and 15 nm (Figure 1). The magnetic properties of $SuRuO_3$ nanodots depend on the size of the nanodots associated with strain and oxygen octahedral rotation, as demonstrated by scanning transmission electron microscopy [2, 3]. In another parallel study, we show that the self-assembly of complex oxide membranes enables the fabrication of faceted nanodots with low defect density (Figure 2) [4]. Our studies highlight the potential for fabricating oxide nanostructures with exotic properties.

References

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[3] Hongguang Wang, Vesna Srot, Bernhard Fenk, Gennadii Laskin, Jochen Mannhart, and Peter A. van Aken. *Micron,* 140 (2021) 102979.
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Figures

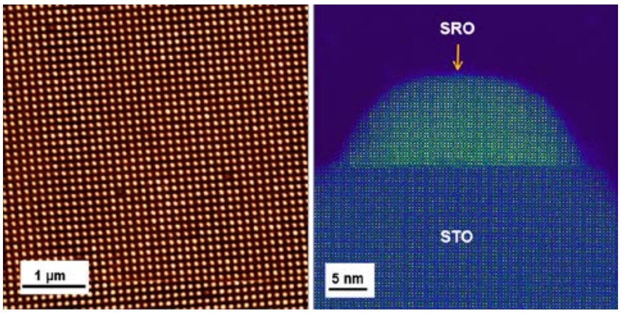

Figure 1: Arrays of nanodots of SrRuO3 with the dot size of 30 nm

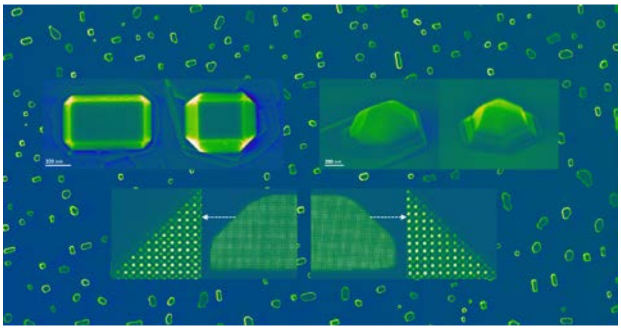

Figure 2: Nanocrystalline structures obtained by self-assembly of oxide membranes