Rapid growth of inch-sized lanthanide oxychloride single crystals

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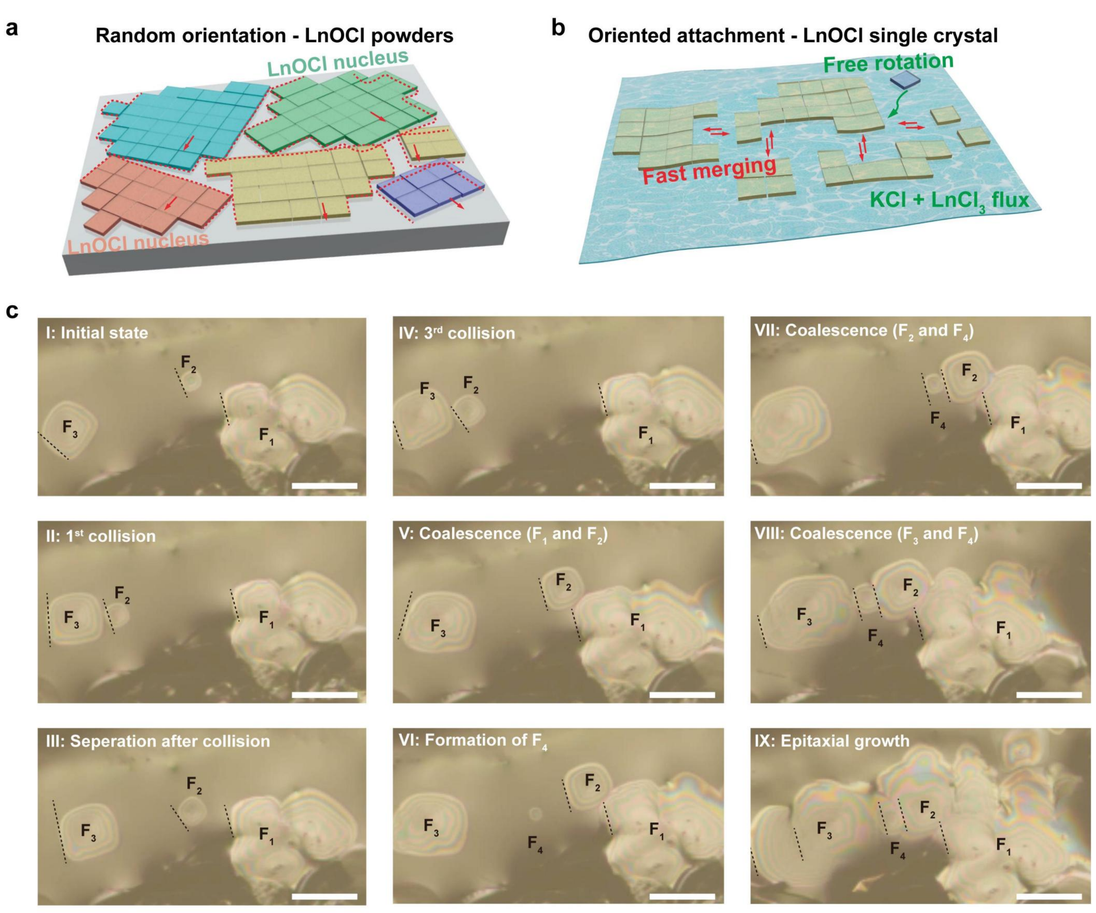
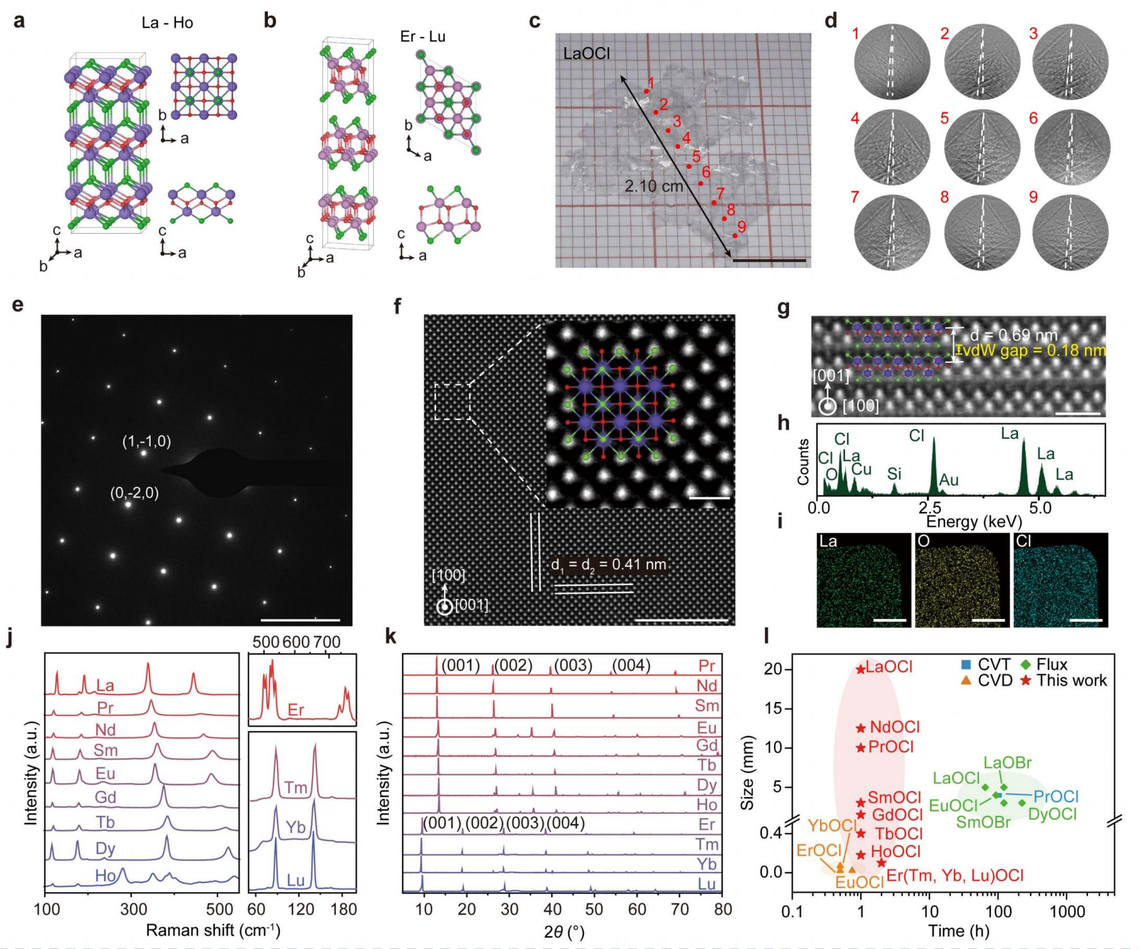
Abstract: Layered lanthanide oxychlorides (LnOCl) family featuring a low equivalent oxide thickness (EOT), high breakdown field, magnetic ordering properties, hold great promise for next-generation van der Waals (vdW) devices. However, the exploitation of LnOCl materials has been hindered by a lack of reliable methods for growing their single-crystalline phases. Here, we achieved the growth of inch-sized bulk LnOCl single crystals and single-crystalline thin films with thickness down to monolayer in a few hours. The monolayer LnOCl exhibits ultralow EOT values, for instance, LaOCl and SmOCl have values of 0.25 and 0.34, respectively. Furthermore, using LnOCl as dielectrics in graphene devices, we demonstrate wafer-scale enhancement of carrier mobility and well-developed quantum Hall effect. The induced strong magnetic proximity effect (MPE) by SmOCl and DyOCl enables efficient interfacial charge transfer with magnetic exchange coupling. This work provides a general strategy for synthesizing large-size single-crystalline layered materials, enriching the library of ultra-low EOT dielectric materials, and two-dimensional (2D) magnetic materials with induced strong MPE.

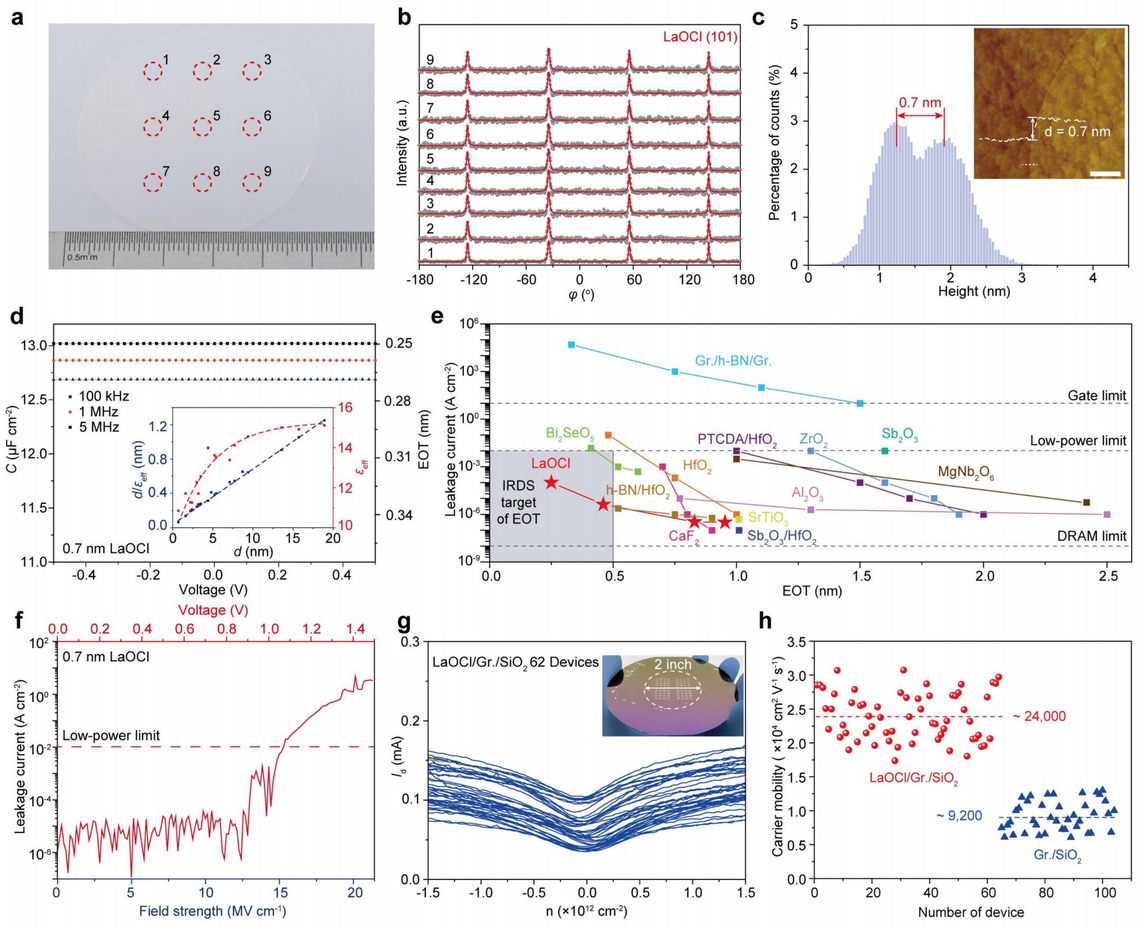
Oriented attachment assisted by KCl flux



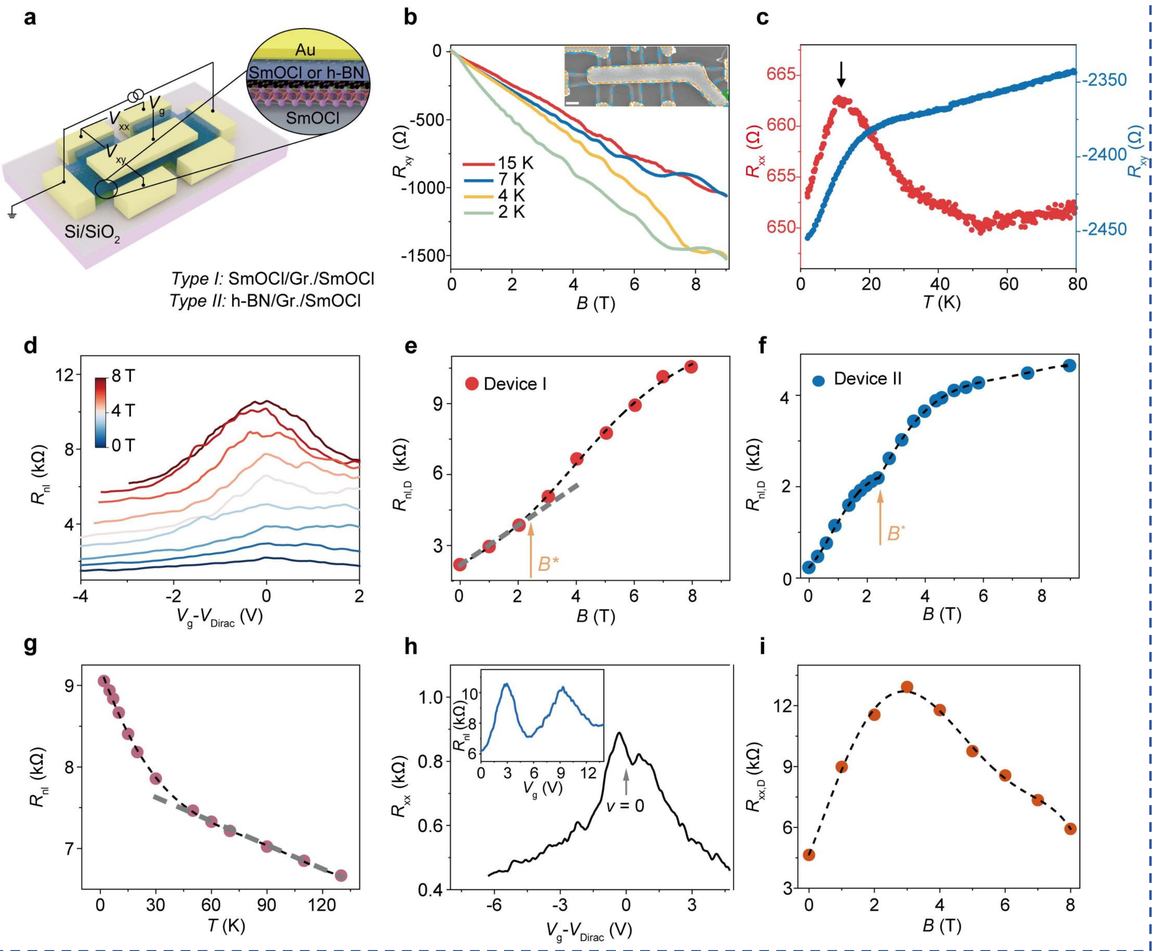
Preparation and exfoliation of LnOCl bulk single crystals



CVD growth of single-crystalline LnOCl (Ln = La and Sm) wafers and their dielectric properties



Transport characterization, ZSHE and MPE of SmOCl-graphene heterostructure devices



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