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Investigation of magnetic proximity effects in epitaxial heterostructures

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Topological states, potentially leading to the formation of Majorana fermions, have been predicted to emerge in heterostructures of an s-wave superconductor (SU) and a semiconductor (SE) with substantial spin orbit coupling and a split band structure [1,2]. Incorporation of ferromagnetic materials, such as ferromagnetic insulators (FMI), into the heterostructures constitutes a promising route for providing the Zeeman energy necessary for splitting the SE bands [3]. The initial step towards development of an intrinsically topological trilayer structure is to ensure the adequate strength of magnetic proximity effects at the different combinations of FMI/SE and FMI/SU interfaces [4].
We present a comprehensive study of the magnetic properties in InAs/Pb/EuS/Pb and InAs/EuS/Pb heterostructures, with thicknesses varying from 20 to 40 nm for Pb and 1.5 to 4 nm for EuS. The films have been grown by molecular beam epitaxy (MBE) and e-beam deposition. Polarized neutron reflectometry (PNR) has been used to quantify the extent of the magnetic proximity at the FMI/SU and FMI/SE interfaces, which is crucial for entering the topological phase.
For InAs/Pb/EuS/Pb, we observe an extension of magnetism from the EuS layer into the neighbouring layers at both interfaces. The results reveal a magnetic moment arrangement that is parallel at lower interface and antiparallel at top interface with respect to the spins in EuS layer. On the other hand, for InAs/EuS/Pb, we observe a parallel arrangement of magnetic moments at both InAs/EuS and EuS/Pb interfaces. This magnetic behavior can be attributed to the quality of the EuS/Pb interface, a decisive factor for influencing the arrangement of spins [5]. XMCD measurements contribute information about the elemental magnetism. The results are complemented with X-ray reflectometry, TEM, XRD and SQUID measurements on structure and magnetism. The understanding of the interfacial magnetism will play a pivotal role in the development of the final device structure.
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Magnetic thin films and interfaces

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