Engineering zero-bias anomaly on insulating surface

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Single atoms or molecular magnets have been extensively investigated in recent decades as potential candidates for next-generation quantum bits (qubits). While one of the crucial challenges in qubit device development has been the need for an extended spin lifetime, this obstacle has been effectively overcome through the implementation of electronically decoupled substrates such as MgO [1], thereby prolonging the lifetime to the order of seconds.

In this study, we have conducted scanning tunneling microscopy/spectroscopy (STM/STS) analyses on atomically smooth and pristine MgO islands cultivated on oxygen-precoated Fe(001) whisker substrates under ultrahigh vacuum conditions at 4.6 K. These MgO islands, with a thickness of approximately 1 nm, exhibit a band gap of approximately 3 eV [2], effectively decoupling electronic interactions from the metallic Fe substrate.

Despite the high-quality nature of the MgO islands (characterized by minimal atomic defects), notable features were observed within the band gap when the metallic W tip picked up a Fe single atom replaced on the MgO surface, indicating the appearance of a zero-bias anomaly (ZBA) peak in the dI/dV curve near the Fermi energy. Since dI/dV curves obtained from various locations on the same MgO island displayed the identical ZBA peak, indicating the ZBA originated by the Fe atom adsorbed at the tip apex. We endeavored to explore the interaction of this ZBA phenomenon with an additional magnetic impurity. Single molecules of Cu-phthalocyanine (S = 1/2) were adsorbed onto the MgO surface. Further elaboration on this matter will be provided.

References:

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