Takashi Uchihashi
International Center for Materials Nanoarchitectonics (MANA), National Institute for Materials Science (NIMS), 1-1, Namiki, Tsukuba, Ibaraki, Japan

UCHIHASHI.Takashi@nims.go.jp

Surface Atomic-layer Superconductors: Novel Rashba effect and Dynamic Spin-Momentum Locking

The recent discovery of superconductivity in atomic-layer materials has attracted extensive attentions from the viewpoint of fundamental physics, materials science, and device applications [1]. Particularly, when atomic layers are epitaxially grown on a substrate surface, the space inversion symmetry breaking should affect superconductivity in general through the manifestation of Rashba effect. In this talk, I will focus on metal atomic layers on semiconductor surfaces prepared in ultrahigh vacuum (UHV) environment, which can be directly probed with state-of-the-art surface science techniques [2-4]. Indium atomic layers on silicon surface, Si(1111)-($\sqrt{7}\times\sqrt{3}$)-In, was found to have a spin-split Fermi surface through laser-based angle-resolved photoemission spectroscopy (ARPES). Intriguingly, the direction of spin polarization in the momentum space is determined by the orbital angular momentum, unlike the conventional Rashba effect [5]. The superconducting transition of this surface atomic layer was studied with a home-developed electron transport measurement apparatus under the UHV environment and strong magnetic fields. The in-plane critical magnetic field was found to reach 3-4 times of the Pauli-limit at zero temperature, which indicates a strong suppression of the paramagnetic pair breaking effect (Figure 1). This is attributed to a *dynamic* spin-momentum locking, where the spin of an electron is forced to flip by every elastic impurity scattering [6]. This mechanism is complimentary to the *static* spin-valley locking in terms of robustness of superconductivity against magnetic field [7].

References

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Figures

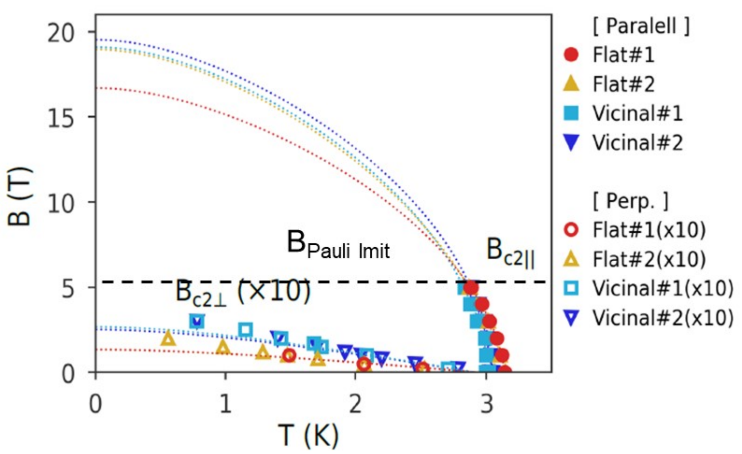

Figure 1: Temperature dependence of in-plane and out-of-plane critical magnetic fields of Si(1111)-($\sqrt{7}\times\sqrt{3}$)-In.