Yuji Nakagawa[1]

Yu Saito[2], Tsutomu Nojima[3], Kei Inumaru[4], Shoji Yamanaka[4],
Yuichi Kasahara[5], and Yoshihiro Iwasa[1,6]

[1] Quantum-Phase Electronics Center and Department of Applied Physics, The University of Tokyo, Hongo 7-3-1, Bunkyo-ku, Tokyo 113-8656, Japan

[2] California Nanosystems Institute, University of California at Santa Barbara, Santa Barbara, CA, 93106, USA

[3] Institute for Materials Research, Tohoku University, Katahira 2-1-1, Aoba-ku, Sendai, Miyagi 980-8577, Japan

[4] Department of Applied Chemistry, Hiroshima University, Kagamiyama 1-4-1, Higashi-Hiroshima, Hiroshima 739-8527, Japan

[5] Department of Physics, Kyoto University, Kitashirakawa Oiwakecho, Sakyo-ku, Kyoto 606-8502, Japan

[6] RIKEN Center for Emergent Matter Science (CEMS), Hirosawa 2-1, Wako, Saitama 351-0198, Japan

nakagawa@mp.t.u-tokyo.ac.jp

Gate-controlled two-dimensional superconductors approaching BCS-BEC crossover

Gate-control of two-dimensional (2D) superconductivity via electric field has been attracting enormous interests as represented by $SrTiO_3$, transition metal dichalcogenides, and magic-angle twisted bilayer graphene [1]. In this presentation, we demonstrate that the gate-control of electrochemical intercalation processes (Fig. 1a) offers a new opportunity to study exotic phenomena in 2D superconductors [2]. We achieved the superconductivity in the low carrier-density limit of layered nitrides (ZrNCl and HfNCl) by the intercalation of lithium. The superconducting critical temperature T_c is enhanced up to 25 K as the system approaches the non-doped semiconducting phase (Fig. 1b). Such behavior is distinct from other superconductors with dome-shaped phase diagrams. The strongly coupled, low carrier density superconductors are promising candidates to observe a crossover from the Bardeen-Cooper-Schrieffer (BCS) limit to the Bose-Einstein condensation (BEC) limit, which has been studied in ultra-cold Fermi gas system [3]. We searched its features by combining transport measurements and tunneling spectroscopies, and the systematic development of the pseudogap phase was detected. This work sheds new light on the study of BCS-BEC crossover in condensed matter systems, and the exploration of novel 2D superconductors.

References

[1] Y. Cao *et al.*, *Nature* **556**, 43-50 (2018).
[2] Y. Nakagawa *et al.*, *Phys. Rev. B* **98**, 064512 (2018).
[3] M. Randeria and E. Taylor, *Annu. Rev. Condens. Matter Phys*. 5, 209 (2014).

Figures

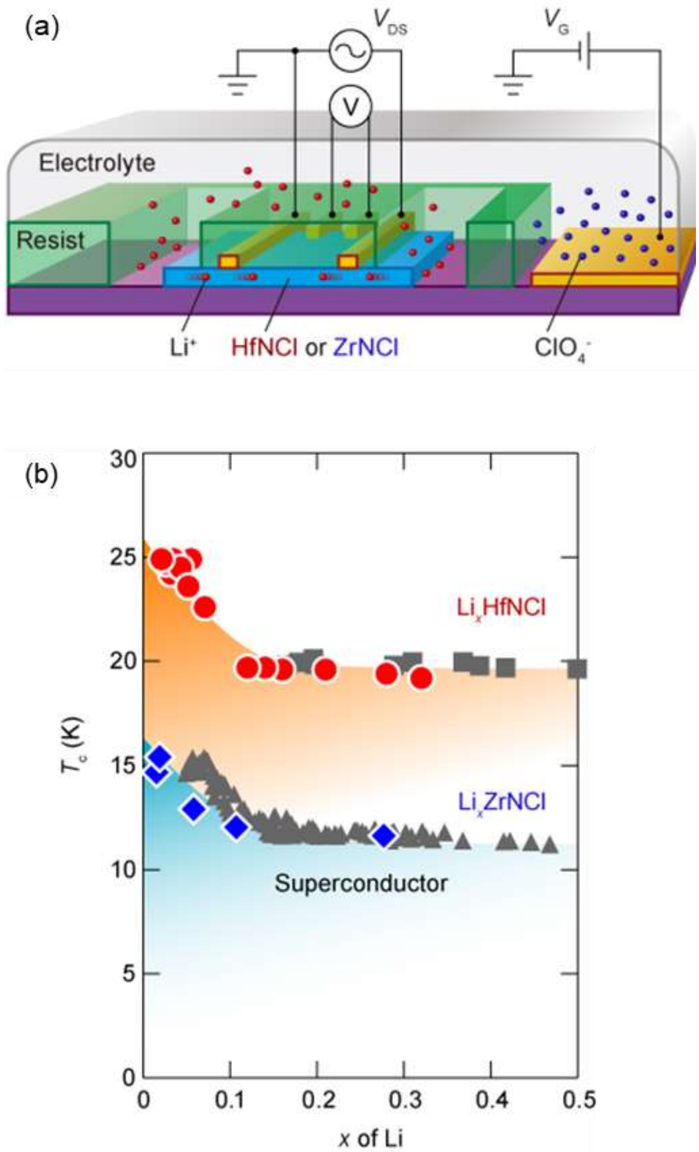

Figure 1: (a) Schematic of the device for intercalation. Lithium ions are intercalated to the crystal driven by a gate voltage V_G. (b) Phase diagram of layered nitrides. Red circles and blue diamonds indicate T_c of HfNCl and ZrNCl, respectively. T_c shows the highest value in the vicinity of the semiconducting phase (x = 0).