Ambient pressure growth of nickelate single crystals with superconductivity over 90 K under high pressure

(Session 1, Invited talk)

Feiyu Li,[1†] Zhenfang Xing,[2†] Di Peng,[3,2*] Jie Dou,[4,5] Ning Guo,[6] Liang Ma,[4,7,8] Yulin Zhang,[1] Lingzhen Wang,[1] Jun Luo,[4] Jie Yang,[4] Jian Zhang,[1] Tieyan Chang,[9] Yu-Sheng Chen,[9] Weizhao Cai,[10,11] Jinguang Cheng,[4,5] Yuzhu Wang,[12] Zhidan Zeng,[2] Qiang Zheng,[6] Rui Zhou,[4,5] Qiaoshi Zeng,[2,3*] Xutang Tao,[1*] and **Junjie Zhang**[1*]

[1]State Key Laboratory of Crystal Materials, Institute of Crystal Materials, Jinan, Shandong 250100, China

[2]Center for High Pressure Science and Technology Advanced Research, Shanghai 201203, China

[3]Shanghai Key Laboratory of Material Frontiers Research in Extreme Environments (MFree), Institute for Shanghai Advanced Research in Physical Sciences (SHARPS), Shanghai 201203, China

[4]Beijing National Laboratory for Condensed Matter Physics and Institute of Physics, Chinese Academy of Sciences, Beijing 100190, China

[5]School of Physical Sciences, University of Chinese Academy of Sciences, Beijing 100190, China

[6]CAS Key Laboratory of Standardization and Measurement for Nanotechnology, CAS Center for Excellence in Nanoscience, National Center for Nanoscience and Technology, Beijing 100190, China

[7]Key Laboratory of Materials Physics, Ministry of Education, School of Physics, Zhengzhou University, Zhengzhou 450001, China

[8]Institute of Quantum Materials and Physics, Henan Academy of Sciences, Zhengzhou 450046, China

[9]NSF's ChemMatCARS, University of Chicago, Lemont, Illinois 60439, United States

[10]School of Materials and Energy, University of Electronic Science and Technology of China, Chengdu 611731, Sichuan, China

[11]Huzhou Key Laboratory of Smart and Clean Energy, Yangtze Delta Region Institute (Huzhou), University of Electronic Science and Technology of China, Huzhou 313001, China

[12]Shanghai Synchrotron Radiation Facility, Shanghai Advanced Research Institute, Chinese Academy of Sciences, Shanghai, China

Abstract: Recently, the Ruddlesden-Popper bilayer nickelate $La_3Ni_2O_7$ has emerged as a superconductor with a transition temperature (T_c) of ~ 80 K above 14 GPa. Efforts to search for nickelate superconductors with higher T_c, to grow reproducible high-quality single crystals, and to eliminate reliance on demanding high gas pressure synthesis conditions, remain significant challenges. Here we report superconductivity up to 92 K ($T_{c,max}^{onset}$ = 92 K and $T_{c,max}^{zero}$ = 73 K @ 21 GPa) under high pressure in single crystals of bilayer nickelate synthesized at ambient pressure using flux methods. Notably, higher $T_{c,max}$ correlates with larger in-plane lattice distortion at ambient conditions for bilayer nickelates. Furthermore, we observed a structural transition from monoclinic $P2_1/a$ to tetragonal $I4/mmm$ at ~ 18 GPa, indicating that tetragonal structure is not a prerequisite for superconductivity to appear in this bilayer nickelate. This study provides an easy-to-access method for growing reproducible high-quality bilayer nickelate single crystals and offers new insights into achieving higher T_c superconductivity. [1]

[1] Li et al. arXiv: 2501.14584 (2025).