Supplementary material for Temperature-driven Topological Phase Transition and Intermediate Dirac Semimetal Phase in $ZrTe_5$

B. Xu,[1,*] L. X. Zhao,[2] P. Marsik,[1] E. Sheveleva,[1] F. Lyzwa,[1] Y. M. Dai,[3] G. F. Chen,[2] X. G. Qiu,[2] and C. Bernhard[1]

[1] *University of Fribourg, Department of Physics and Fribourg Center for Nanomaterials, Chemin du Musée 3, CH-1700 Fribourg, Switzerland*

[2] *Beijing National Laboratory for Condensed Matter Physics, Institute of Physics, Chinese Academy of Sciences, P.O. Box 603, Beijing 100190, China*

[3] *Center for Superconducting Physics and Materials, National Laboratory of Solid State Microstructures and Department of Physics, Nanjing University, Nanjing 210093, China*

Reflectivity measurements

The polarized reflectivity $R(\omega)$ with $\mathbf{E}\|a$-axis and $\mathbf{E}\|c$-axis was measured at a near-normal angle of incidence using a Bruker VERTEX 70v FTIR spectrometer. In order to accurately measure the absolute $R(\omega)$ of the sample, an *in situ* gold overcoating technique [1] was employed. Data from 20 to 8 000 cm^{-1} were collected at 14 different temperatures from 300 down to 10 K on a shiny surface of $ZrTe_5$ in an ARS-Helitran crysostat. Since a Kramers-Kronig analysis requires a broad spectral range, the room temperature $R(\omega)$ in the near-infrared to ultraviolet range (4 000 – 50 000 cm^{-1}) was measured with a commercial ellipsometer (Woollam VASE).

Kramers-Kronig analysis

The real part of the optical conductivity $\sigma_1(\omega)$, which provides direct information about the charge dynamics, has been determined via a Kramers-Kronig analysis of $R(\omega)$ [2]. Below the lowest measured frequency, we used a Hagen-Rubens function ($R = 1 - A\sqrt{\omega}$) for the low-frequency extrapolation. For the extrapolation on the high frequency side, we used the room temperature ellipsometry data and extended them assuming a constant reflectivity up to 12.5 eV that is followed by a free-electron (ω^{-4}) response.

* bing.xu@unifr.ch

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