Contribution ID: **205** Type: **Oral Presentation**

The Ultrafast Photo-Induced Metal-Insulator Phase Transition in Organic Cu(DCNQI)₂ Observed with Ultrafast Electron Diffraction

Wednesday, 5 July 2017 14:20 (20 minutes)

The 1-dimensionally conductive organic material Cu(DNCQI)₂ has been a subject of interest due to its exotic macroscopic (conductivity) properties and the tuneability thereof. Depending on chemical composition, the crystal loses many orders of magnitude of conductivity within 1 K upon cooling. This phase transition is associated with a structural ('Peierls') transition of the (microscopic) lattice, where three crystal planes move together and form trimers. Despite the presence of a crystal lattice rearrangement, until now the only successful time resolved studies on Cu(DCNQI)₂ are on macroscopic properties of the material, such as ultrafast photoinduced conductivity measurements in bulk needles. We present the first study ever on this crystal (we used Me,Br-DCNQI, T_{transition} = 155 K) that reveals the microscopic molecular response on an ultrafast time scale, by using Ultrafast Electron Diffraction (UED).

The main findings of this study are the ultrafast (˜2ps) full suppression of the insulating trimer phase and a full recovery thereof within ˜40ps, which is one of the fastest macroscopic structural lattice phase transitions ever seen. We also observe an ultrafast change of the structure within the planes, linked to a distortion of the tetrahedral geometry of the crystal, with a slow (>ns) recovery. The successfully resolved molecular response (and the extracted ultrafast time constants) aid in understanding the underlying mechanisms of the photo-switched insulator-to-metal transition.

Apply to be
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Yes

Level for award
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PhD

Main supervisor (name and email)
and his / her institution

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Session Classification: Photonics

Track Classification: Track C - Photonics