



## SCDT – FlexE Centre Webinar Series

*The webinars aim to bring together researchers in Flexible Electronics and allied areas from across India (and other countries) on a single platform to promote professional interaction.*

### Webinar by



### Professor Subhasis Ghosh

Professor, School of Physical Sciences  
Jawaharlal Nehru University, New Delhi

### On “Hopping to Band-like Transport in Molecular Organic Semiconductors”

**Date:** 12<sup>th</sup> October, 2021

**Time:** 4:00 PM to 5:00 PM

Visit [www.iitk.ac.in/scdt/webinars.html](http://www.iitk.ac.in/scdt/webinars.html)  
to access the zoom link to join the  
webinar.

The event will be chaired by

**Prof. Supravat Karak**

Indian Institute of Technology Delhi

### Abstract of the Webinar

Low values of charge carrier mobility in organic thin films is a fundamental issue affecting their applications to integrated circuits, displays and memory devices requiring fast processing. Intrinsic thermal and structural disorder in organic thin films lead to localization of charge carriers resulting in low carrier mobility due to an inefficient transport process by which carriers move from one site to site state by hopping. However, charge transport in organic semiconductors in their single crystalline phase is coherent due to band conduction and mobility is not limited by disorder resulting in higher carrier mobility. So it is a challenge to enhance the carrier mobility in a thin film which is the preferred choice for all organic devices. Here, we show that it is possible to increase the carrier mobility in polycrystalline thin films by injecting sufficient carriers such that Fermi level can be moved into the region of high density in Gaussian density of states in molecular solids. When the hopping transport happens through the molecular energy levels whose density is low, mobility is decided by incoherent transport however, when the hopping transport happens through the energy levels with high density, mobility is decided by coherent transport, as in band conduction. We present results highlighting the observation of both band-like and hopping conduction in polycrystalline organic thin films by varying the concentration of injected charge. More importantly the transition from hopping to band transport is reversible. By studying the transistor characteristics of a pentacene and CuPc thin films in both negative and positive source-drain bias regime, we have shown that different transport regimes can be observed. The large difference in mobility in positive and negative source-drain bias regime has been explained on the basis of position of the Fermi level. In positive source-drain bias regime, mobility comparable with single crystal of pentacene has been obtained due to the Fermi level lying near the center of the GDOS for the whole channel. The crossover between the two regimes has been shown to result from the movement of the Fermi level to a region of high density of states. The observed carrier mobility in both the regimes match well with theoretical estimates of hopping mobility within the Marcus model, and band mobility estimated using first principles density functional theory.

### Information about the speaker

Professor Subhasis Ghosh is a professor of physics in the School of Physical Sciences, Jawaharlal Nehru University, New Delhi. He graduated from University of Calcutta, Kolkata and received his Ph.D. from the Department of Physics, Indian Institute of Sciences, Bangalore. Then he spent couple of years at Max Planck Institut fur Festkorperforschung, Stuttgart, as research associate. He is also visiting faculty in the School of Electrical and Computer Engineering, Purdue University, West Lafayette, Indiana. He has published more than 100 papers in reputed research journals. His present research interests are, (i) skyrmions in chiral magnets, (ii) phase transition and critical phenomena in 2d van der Waals and skyrmion host materials (iii) organic semiconductors and organic field effect transistors, and (iv) graphene.