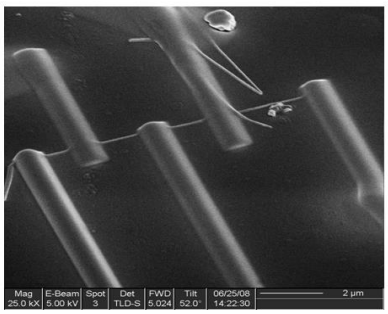
Nanolithography activities in Bose Centre clean room by AKR Group

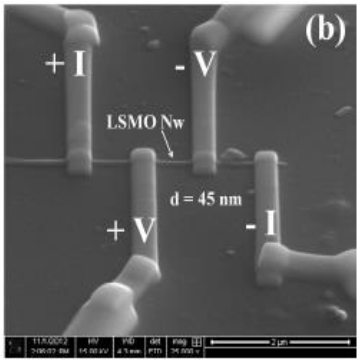
Visit of the Honourable Union Minister for Science and Technology and Earth Science to the Bose Centre Clean room on May 3,2015. (Standing in front of Helios machine, 2nd from left)

AKR group has extensive activities in the area of nanolithography. The work is done in a Clean room of the centre which has been established with support form the Nanomission Projects. This is a class 10,000 class room which is maintained at class 1000 in specific areas. The facilities in the clean room allow optical lithography, electron beam lithography (EBL) and focused ion beam (FIB) lithography. One of the activities that is carried out on a routine basis is to integrate sub- 100nm nanowire of any material produced by bottom-up approach like chemical route or physical/chemical vapour deposition to a single nanowire device connected to 2 or 4 probes. Nanowires from vapour phase are also grown as nanobridges between submicron contacts made by EBL. Integrating the rich materials base of bottom-up approach with nanolithograhic process is a strength of AKR group. For attaching nanowires to prefabricated contact pads for opt-electronic or electronic measurements in addition to EBL –lift off, FIB or Focused electron beam deposited metals (Pt or W) are also used.

As a part of collaborative work FIB produced anti-dot lattice or array of holes have been made as a magnonic material or as strained ordered islands for growth of Ge quantum dots.
Some of the representative work done by the group are shown below. A list of facilities are in the attached list

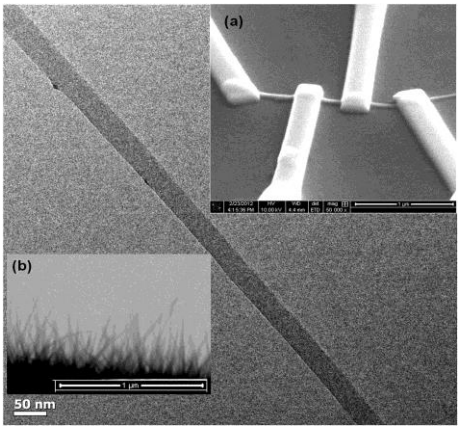


A Ni nanowire (55nm diameter x 5 µm length) connected by Pt deposited Pt leads . Lead width 200nm
(2009) "Temperature dependent electrical resistivity of a single crystalline ferromagnetic nanowire"
Appl.Phys.Letts. **95**, 013112

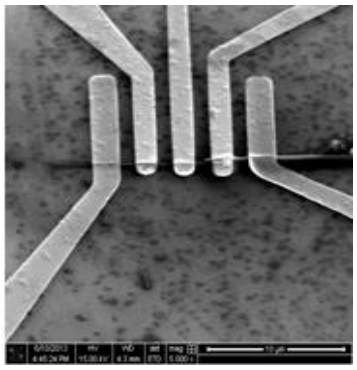


A manganites nanowire(45 nm) connected by FEB deposited Pt.
(2014) "Low-Frequency Resistance Fluctuations in a single nanowire (diameter _ 45nm) of a complex oxide and its relation to magnetic transitions and phase separation"
Applied Physics Letters ***105****, 073117;*

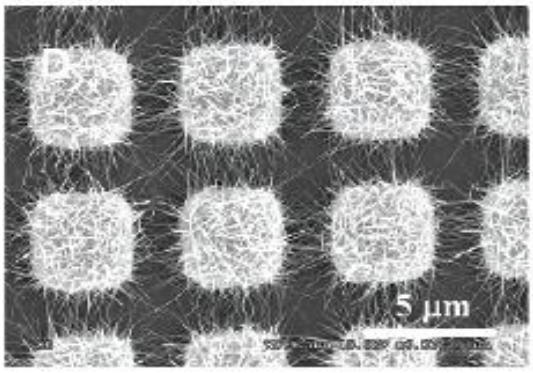
Collaborator: Dr.Barnali Ghosh (SNBNCBS)



A 30nm Cu:TCNQ nanowire connected to 4 probe for optical detector application. The Pt probes (200nm width) were deposited by FEB
(2014) "Single CuTCNQ charge transfer complex nanowire as ultra high responsivity photo-detector",OPTICS EXPRESS 22 , 4944 (2014)

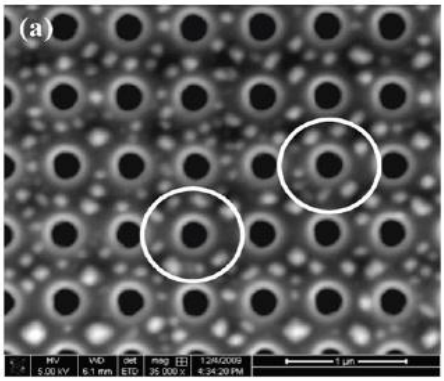


A 80nm Si nanowire (total length 10μm) connected to Au/Cr contacts fabricated by EBL-lift off. For sensor application as well as for noise measurement.
(2014) "Single Si nanowire (diameter ≤ 100nm) based polarization sensitive near-infrared photodetector with ultra-high responsivity."
RSC- Nanoscale ***6*** *, 1123*
Collaborator .Dr.S.K.Ray (IIT/Kgp)
(2013) "Low frequency °ficker noise in a MSM device made with single Si Nanowire (diameter~50nm)"
Nanoscale Research Letters , **8** 165



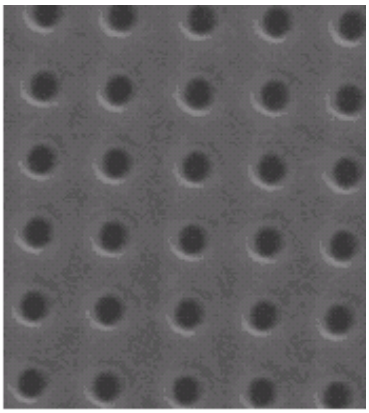
Nanobridge optical detector fabricated by vapor phase deposition of CuTCNQ within pre-fabricated contact pads made by EBL lift-off
(2013) "**Large photoresponse of Cu:TCNQ nanowire arrays formed as aligned nanobridges".**
Appl. Phys. Lett. **102**, 061111 ;

Collaborative work



Array of holes (100nm diameter, 160nm pitch) drilled in Si for strain mediated alignment of Ge Quantum dots around them.
(2012) "Preferential ordering of self-assembled Ge islands on focused ion-beam patterned Si(100)"
J Nanopart Res . **14**, 725

Collaborator : Dr.S.K.Ray (IIT/Kgp)



Anti dot array (100nm hole x200nm spacing) grown on 25nm Co film as a magnonic 2D crystal (Total array 10 μm x10μm)
(2012) "Optically Induced Tunable Magnetization Dynamics in Nanoscale Co Antidot Lattices"
ACS NANO **6** 3397 .
Collaborator : Dr. Anjan Barman (SNBNCBS)

Major Facilities in the clean room for nanolithography

AKR group has a dedicated clean room facility (class 1000+) that is used in its nanofabrication work. The facility houses a combination of optical lithography, electron-beam facility and focused ion beam nanolithography tools that allows extensive nanodevice fabrication. At present the group can fabricate devices based on single nanowires with diameter as low as 20nm or create patterns using the focused ion beams with feature sizes down to 20nm. The nanolithography facility was created mainly with project supports under Nanomission.

Helios 600 dual beam machine (FEI)	This machine is a combination of focused Ga ion beam (FIB) , electron beam (FEG-SEM) and localized precursor based deposition unit. The ion beam and electron beam writing as well as metal deposition (W and Pt) can be done using a CAD based pattern generator . The machine is extensively used for lift-off based nanolithography using electron beam lithography (EBL) and

	allows 100nm pattern creation.. At present the Helios 600 have precursors for Pt and W deposition using both Focused Ion Beam as well as Focused Electron Beam deposition.
Mask – aligner (EMA-400)	The mask-aligner is used for optical lithography work for pattern generations down to 5μm.
ICP-RIE Plasma etching unit **(SENTECH 500)**	A RF Plasma unit that can etch materials in gas phase. Used for transferring patterns and in making plasma etched nanostructures.
UHV metallization unit **(SVT)**	An evaporation unit that uses e-beam evaporation at vacuum in low 10^{-7} to 10^{-8} torr range.