welcome to the European Microkelvin Collaboration

CAPACITIES

Report on the Transnational Access Activity carried out within MICROKELVIN

The eligibility of transnational access to a MICROKELVIN TA site implies the submission of the following:

1) The Certification of visit

The form "Certification of visit" must be completed and signed by the access provider in charge of the infrastructure and the leader of the project.

2) A TA project report

The form for the TA project report is contained within this document. It should be completed after project end by the group leader of the project. You must respect the limited number of words specified, longer descriptions will be rejected. Figures/tables may be attached at the end of the document. The document must be submitted in an editable format (doc, rtf).

3) A User group questionnaire

To enable the Commission to evaluate the Research Infrastructures Action, to monitor the individual contracts, and to improve the services provided to the scientific community, each project leader of a user-project supported under an EC Research Infrastructure contract is requested to complete a "user group questionnaire". The questionnaire must be submitted once by each user group to the Commission as soon as the experiments on the infrastructure come to end.

The user group questionnaire is not part of this document and must be completed on-line. It is accessible at:

http://cordis.europa.eu/fp7/capacities/questionnaire_en.html.

► Please note that any publications resulting from work carried out under the MICROKELVIN TA activity must acknowledge the support of the European Community:

> **"The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 228464 (MICROKELVIN)."**

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CAPACITIES

MICROKELVIN Transnational Access Project Report

1. General information

Project number:	**CNRS 16**	
Project Title:	**The electron Glass in Semiconductors**	
Lead scientist:[1]	**Title:**	Professor
	First name:	Aviad
	Last name:	Frydman
	Home institution:	Bar Ilan University, Israel
Host scientist:[2]	**Title:**	Dr.
	First name:	Thierry
	Last name:	Grenet
	Home institution:	Neel Institute, CNRS, Grenoble
Project scientist:[3]	**Title:**	Professor
	First name:	Aviad
	Last name:	Frydman
	Birth date:	9.2.1964
	Passport number:	20537280
	Research status/Position:	
	New User:[4]	
	Scientific Field:	
	Home institution:	
	Is your home institution MICROKELVIN partner?	No
	Business address:	Department of Physics
	Street:	Bar Ilan University
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[1] The lead scientist indicated here is expected to participate in the campaign as a user of the infrastructure.

[2] The host scientist is supervising the work of the visiting project scientist at the infrastructure.

[3] The project scientist is the person who will be visiting the infrastructure.

[4] Indicate 'Yes' only if the user has never visited the infrastructure before this specific project, otherwise write 'No'.

2. Project information

Please, give a brief description of project objectives: (250 words max)	The electrical conductivity in highly disordered electronic hopping systems, which are subject to strong electronic interactions, exhibits glassy phenomena such as slow relaxation to equilibrium, memory effects, and aging (as representative of an "electron glass"). So far electron glass properties have been seen only in highly disordered metals or metal-like materials exhibiting hopping transport and having charge carrier densities larger than n = 10^{20} cm^{-3}. No clear signs for glassy effects were observed in semiconductors. It has been proposed that an electron glass requires a hopping system characterized by a large number of charge carriers within a localization length. A semiconductor has a relatively small charge carrier density. Hence, in order to fulfill the above requirement one would need a relatively high degree of doping, in order to increase the localization length, and very low temperatures so that transport in the semiconductor is dominated by the hopping conductivity. In this project, we explored the electron glass phenomena in semiconducting samples at ultra-low temperatures. Despite decades of research, many aspects of the electron glass are not understood. No statistical or thermodynamic theory of non-ergodic systems exists and therefore there is no full understanding of any glasses, even less so of the electron glass that may be a special case of a "quantum glass". Hence the situation in semiconductors is very important. We trust that the information gained by exploring the electron glass in heavily doped semiconducting samples will provide useful information for a deeper understanding of the processes responsible for glassines in low dimensional electronic systems.
Technical description of work performed: (250 words max)	The first stage of the project was dedicated to identifying the correct semiconducting samples. We studied a number of different systems and chose 4 samples: 2 doped bulk silicon samples and 2 samples of 2D films of amorphous diamond. All these samples had carrier concentrations above 10^{18} cm^{-3} and measurable resistances at temperatures smaller than 0.5 K. We studied the electron glass properties of all these samples at different temperatures down to the lowest temperature at which their resistance was measurable. For the silicon samples, a gate was added to explore the field effect. The results were compared to granular aluminum samples which had similar resistances. The Al samples were also measured within the framework of this project.
Project achievements (and difficulties encountered):[5] (250 words max)	We successfully studied the transport properties and the relaxation to equilibrium after quench cooling of 4 different semiconductor samples, two 3D doped Si and two 2D amorphous diamond films. The transport of the films exhibits hopping conductivity with properties similar to those of "classic" electron glasses. The relaxation properties, on the other hand, were very

	different. We were not able to measure any conductivity relaxation after a rapid cool-down in any of semiconducting samples within our measurement resolution. We were able to put an upper bound of $5*10^{-3}$ % on conductivity relaxation in semiconductors (if such exists). This is orders of magnitude smaller than the relaxation observed in dirty metals. For example, we measured a granular aluminium film having similar resistance at low temperatures and observed a conductance relaxation close to 10% 100000 seconds after the cool down. We are now measuring the field effect of the gate voltage on the silicon samples. So far we see no signs of a "memory dip" in the conductance versus gate voltage curve which is one of the fingerprints of electron glasses. We are in the process of performing the data analysis but even in the absence of that it is clear that our results show that semiconductors do not exhibit electron glass effects even in systems having very high carrier concentration – contrary to our expectations. This result is very significant to the understanding of the origin of such effects in disordered conductors and requires new ideas to explain the difference between amorphous Anderson insulators and doped semiconductors.
Expected publications and dates:	▪ Lack of electron glass effects in semiconductors – expected within 3 months.
Submission date of user group questionnaire:	23.8.2013

Completed Project Reports should be returned to MICROKELVIN Management Office (Sari.Laitila@aalto.fi, Fax: +358 9 47022969).

Please complete and sign the form and send it by email or fax to the MICROKELVIN Management Office (leena.meilahti@tkk.fi, Fax No.: +358 9 4512969)

CERTIFICATION OF VISIT

at MICROKELVIN Transnational Access Site

I herewith confirm that the following project was carried out at our Transnational Access Site

CNRS GRENOBLE

in the context of MICROKELVIN Transnational Access:

CNRS-16: The electron Glass in Semiconductors

The amount of access[1] delivered to the project group (project users) is as follows:

	Participant name	Duration of stay (start – end date)	Amount of access[2]
Project leader:	Prof. Aviad FRYDMAN		
Project user 1:	Prof. Aviad FRYDMAN	9/6 to 31/8/13	84 days
Project user 2:	Prof. Aviad FRYDMAN	15/9 to 20/9/2013	6
Project user ...:[3]			
Total amount of access delivered to project group:			**90 days**

Grenoble, September 24th 2013

Location and date

Signature of access provider

Grenoble, September 24th 2013

Location and date

Signature of project leader

Completed Certification of Visit should be returned to MICROKELVIN Management Office (sari.laitila@aalto.fi, fax: +358 9 47022969)

1 TKK Helsinki, CNRS Crenoble, or Lancaster University

2 The amount of access is defined as the time, in days, spent by the user at the infrastructure for this project, including weekends and public holidays (e.g., a scientist who spent 5 days at the infrastructure must indicate '5'). The total amount of access of the project group is the sum of access days of each project user.

3 Please, expand if necessary.