Virginia Commonwealth University NRI/NSF NEB2020 Liaison Visit WebEx Only on June 9, 2015

Attendees:

NRI liaison team	
Web-ex	
	Steve Kramer (Micron), Charles Kuo (Intel); Luigi Colombo (TI); IBM was not represented.
NEB team	
Web-ex	VCU: Supriyo Bandyopadhyay, Jayasimha Atulasimha; STUDENTS: Ayan Biswas, Hasnain Ahmad, Noel D'Souza, Mamun Al-Rashid; UVA: Yunkun Xie; UC-Riverside: Alexander Khitun and Mojtaba Ranjbar; U. Michigan: Pinaki Mazumder and Mahmood Barangi;

Meeting schedule:

Time	**Title**	**Speaker**
12:00 pm	Welcome and introduction to VCU presentations	Supriyo Bandyopadhyay
12:10 pm	Spin neurons and other straintronic systems	Ayan Biswas [VCU student]
12:30 pm	FeGa nanomagnet experiments – strain induced switching	Hasnain Ahmad [VCU student]
1:05 pm	Straintronic logic	Noel D'Souza [VCU student]
1:20 pm	Switching simulations	Mamun Al-Rashid [VCU student]
1:30 pm	Wrap up of VCU work	Jayasimha Atulasimha
1:40 pm	Simulations	Yunken Xie [UVA student, Prof. Avik Ghosh]
2:10 pm	Spin wave devices	Mojtaba Ranjbar [UC-Riverside student, Prof. Alexander Khitun]
2:40 pm	Straintronic circuits and architectures	Mahmood Barangi [U. Michigan student, Prof. Pinaki Mazumder]

Logic components and non-boolean concepts were introduced & their operation reviewed thru modeling/simulation. Most of the measurement work focused on nanomagnetic logic; some successful switching was demonstrated on a small scale. Challenges were identified in new material selection with hi magnetoelastic coupling & low defect density.

While new materials are needed, it's unclear how to screen and/or achieve these. It's suggested that the PIs can look into developing a clear methodology to "build" this new material. For example, predictive modeling may be a guide (a la Butler with his proposal for MgO in MTJs or Yunkun Xie's/Prof. Ghosh's work in this review on identifying a suitable Heusler alloy).

PIs also suggested that strain can be used to switch a free layer in MTJ. Practically speaking, CoFeB is the only material identified for free layers in MTJs. It seems that the piezoelectric material chosen should be of similar crystallinity to the free layer, and this could limit how straintronics can work with MTJs. It's

suggested that this mismatch in crystallinity be thought thru more carefully and work-arounds examined thru thin film metrology. For example, amorphous non-magnetic barriers between the piezoelectric and free layers can be studied to see if sufficient strain can be transferred while achieving distinct crystalline structures between different films.