Department of Engineering – Risk Assessment Ref No. B967

Title of project/experiment/activity:

Assembly of layered material heterostructures in inert atmosphere

Location of activity	**Start and end dates**
EEDB Annexe, 2nd floor CGC Cleanroom (Class 1000)	01/07/2017 - continuous

Brief description (or attach procedure/protocol)

A glove box operated with argon encloses a microscope, a spin coater, a hot plate and a thermal evaporator. The microscope, operated through manipulators from outside the glove box, is used for the assembly of layered material heterostructures. Samples are then spin coated with resist and soft-baked on a hot plate. After e-beam lithography in a separate environment the samples are re-inserted in the glovebox for thermal evaporation of metal contacts. This equipment, provided by MBraun and Graphene Industries, is commercially made and will be used in accordance with the manufacturer instructions.

List of Chemicals/Gases/Substances:
Anhydrous or dried solvents: *isopropanol, ethanol, acetone, chloroform, anisole, methyl isobutyl ketone*
Metal pellets or wires: *aluminium, chromium, titanium, gold, platinum, palladium*
Gases: *argon*
Polymers: *poly-methyl-methacrylate, polycarbonate, polypropylene carbonate, polydimethylsiloxane, polyvinyl alcohol*

Hazard	Effect	Control measures	Residual risk
Slips, trips, and falls	Minor injury *Likelihood: 1* *Severity: 1*	Ensure work area is free (as is practicable) from trailing cables, tools, materials, debris, and spills. All work should be from a suitable and stable work platform.	Low risk
Chemicals	Exposure to chemicals harmful to health *Likelihood: 1* *Severity: 1-3*	(Only) Solvents will be used in small quantities inside the glove box. Chemicals and disposal bottles will be sealed when transferred from the glove box to the fume cupboard or cabinet. In the Cleanroom, users will only be using chemicals in the appropriate wet-benches. Cleanroom rules must be respected.	Low risk
Electric shock	Shock to user, damage to equipment *Likelihood: 1* *Severity: 1-2*	Check condition of leads and plugs before use. Do not work where water is present without specialist advice. All mechanical and high voltage parts are enclosed or in a service corridor.	Low risk
Heat sources	Burns *Likelihood: 1* *Severity: 1-2*	If hot plate is hot (in use), other procedures must be carried out at sufficient distance from hot plate to avoid contact. Do not leave unattended. Do not exceed 200°C. Solvents must never be baked. When using evaporator user must allow cooling down of the evaporating source	Low risk

		by waiting at least 10 minutes before venting.	
Fire	Burns *Likelihood: 1* *Severity: 1-3*	All operations in the glovebox are carried out in inert atmosphere (including evaporator venting), hence minimizing the chance of fire. Solvents will be stored at a sufficient distance from the hot plate to prevent spillage, and only in quantities <100ml. Any operation with flammable compounds must be halted immediately in case of oxygen leaks in the glovebox. Regeneration, made by using hydrogen and argon, can cause fire: this procedure will therefore be covered by a separate risk assessment and made by trained technicians. No operation will be carried out during glovebox regeneration.	Low risk
Gas Leak	Explosions *Likelihood: 1* *Severity: 1-2*	Monitor that the glove box pressure is stable. Cleanroom has continuous gas monitors for oxygen.	Low risk

Personal Protective Equipment required [*eye/face protection, respiratory protection, gloves, lab coat etc*]

Overalls, gloves end eye protection must be worn in the Cleanroom at all times.

Emergency Instructions & First Aid

Fire:
In case of fire, evacuate the building immediately. The fire alarm should be sounded and fire service called.

First aid:
General advice: Consult a physician. Show this safety data sheet to the doctor in attendance. If inhaled: move person into fresh air. If not breathing, give artificial respiration. Consult a physician. In case of skin contact: take off contaminated clothing and shoes immediately. Wash off with soap and plenty of water. Take victim immediately to hospital. Consult a physician. In case of eye contact: Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.

Gas Leak:
If the leak triggers the clean room gas alarm, evacuate the building immediately.

Burn:
In the event of burn, rinse with running water and seek first aid if necessary. Report any incident.

Any special monitoring required [*e.g. hearing test, vibration monitoring, health surveillance*]

No

Further control measures required? If yes, list with actions.

Users are forbidden to perform any maintenance task. Users must refer to the facility manager (Dr. Yury Alaverdyan) for maintenance.

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Waste disposal procedures: unchlorinated and chlorinated solvent wastes should be disposed in two separate, dedicated containers inside the glove box and transferred sealed to the wet bench.

In the case of equipment malfunction/failure: shutdown instrument from emergency button or directly from plug socket.

Gloves, eye protection, overalls must be worn during the whole process. The equipment must only be used by those approved by Domenico De Fazio after appropriate training. The cleanroom rules will be respected.

The load-lock transfer procedure could lead to bottle failure. Containers will thus have to be vacuum-proof and approved by Domenico De Fazio before being used inside the glovebox.

Biological/Laser/Radiation Approval [*requires relevant Specialist Safety Officer signature and date*]

N/A

Out of hours/Lone working

The system can be operated out of hours with permission from Head of Division, only if a buddy is nearby and checks regularly that everything proceeds regularly. The system cannot be used overnight.

Signature to confirm that this is a suitable and sufficient assessment of risk and that stated control measures are in place. This risk assessment should be reviewed if additional risks not covered in this assessment are identified or if there is any reason to indicate that the control measures are insufficient.

Name of Assessor Domenico De Fazio Email: dd429@cam.ac.uk	**Signature** Domenico De Fazio	**Date** 06/07/2017
Name of Supervisor Prof. Andrea Ferrari Email: acf26@cam.ac.uk	**Signature**	**Date**
Facilities Manager (countersignature) Dr. Yury Alaverdyan Email: facilities@graphene.cam.ac.uk	**Signature**	**Date** 6/7/17

Local Safety Coordinator Dr. David Hasko	**Signature** David Hasko	**Date** 06/07/2017
Departmental Safety Office IAN SLACK	**Signature**	**Date** 27 JUL 2017