Argonne NATIONAL LABORATORY

PC Growth and Characterization Facility Introduction

The PC-Group

U.S. DEPARTMENT OF ENERGY

Why Do We Want a Growth and Characterization Facility

- **Scientific goals:**
  - **Device Physics:** Study fundamental correlation between structure and functionality of the cathode
  - **Materials Sciences**: Develop microscopic models of the growth and activation process
  - **Device Engineering:** Develop reliable and high yield growth and activation procedures resulting PC's with high QE(>40%) and low dark current
- **Engineering Goals:**
  - Development of evaporators with easy control parameters (measuring xyz and knowing how many atoms where evaporated)
  - Defining process control parameters and the acceptable variations during the process
  - Test of process control units
- **Quality Controls and Quality Assurance program**
  - Test-run for different batches on small format cathode
  - Trouble shouting

Which Cathodes will be Studied

- Bi-Alkali:
  - Collaboration with Kathy Harkay/John Smedley
  - Main scientific questions:
    - Understanding film structure (chemical phases, crystal orientation, size of crystallites, amorphous contribution) and morphology (roughness, correlation with underlaying crystallites, global and local [resolution of crystallites size] surface composition).
    - Influence of substrate on growth characteristics (selective growth, growth suppression) and electronic properties (band pinning).
    - What would be the best crystallite structure (composition, size orientation,….; correlation with thickness optimization?)
  - Engineering targets:
    - Does ion-current provide a good emission monitor and how difficult it is to measure
    - Can we establish a fully computer controlled production protocol
    - How often do we have to change the sources
  - Quality control:
    - Test run for batches of glass
    - Test run for evaporator material

Which Cathodes will be Studied

- GaAs-based cathode
  - Collaboration with Xiuling Li (& Daryl Cozier?)
  - Main scientific questions:
    - Optimizing doping profile to achieve optimized cathode for given wavelength range (thick cathode with well defined transient time independent from absorption position).
    - Developing cost efficient transfer and bonding method.
    - Understanding and minimizing dark current & achieving robust cathode structure
  - Engineering targets:
    - Cleaning and surface preparation protocol (wet-chemistry versus plasma cleaning)
    - Fully automatic activation protocol using alternative process-parameters
    - How to engineer large area activation unit (evaporators/O-handling system)
  - Quality control:
    - Test run for new batches
    - Test run for new Cs evaporators

Which Cathodes will be Studied

- Other structures:
  - GaN: amorphous growth
  - Nano-structures?

What is it What We Have To Measure Bi-alkali

- The physics:
  - Substrate (ex-situ): surface morphology; fermi level; characterization of dopents
  - Cathode: crystalline structure; chemical composition (global/local); chemical phases; surface morphology and composition
  - Functionality: QE(E), time response, momentum response
- The method:
  - Substrate: ex-situ STM/AFM, TEM/SEM?, XPS/UPS, UV-Vis spectroscopy, conductivity measurements
  - Cathode: WAXS/SAXS to characterize crystalline structure (APS), XAFS to characterize amorphous materials and grain boundary (APS), AFM/STM surface composition, XPS/ UPS chemical composition and electronic levels (complementary to X-ray work)
  - Functionality: High intensity 3 wavelength QE measurement (fast detection); wavelength dependent QE measurement (monochromator); Matth's laser-experiment; APRES in collaboration with Kathy

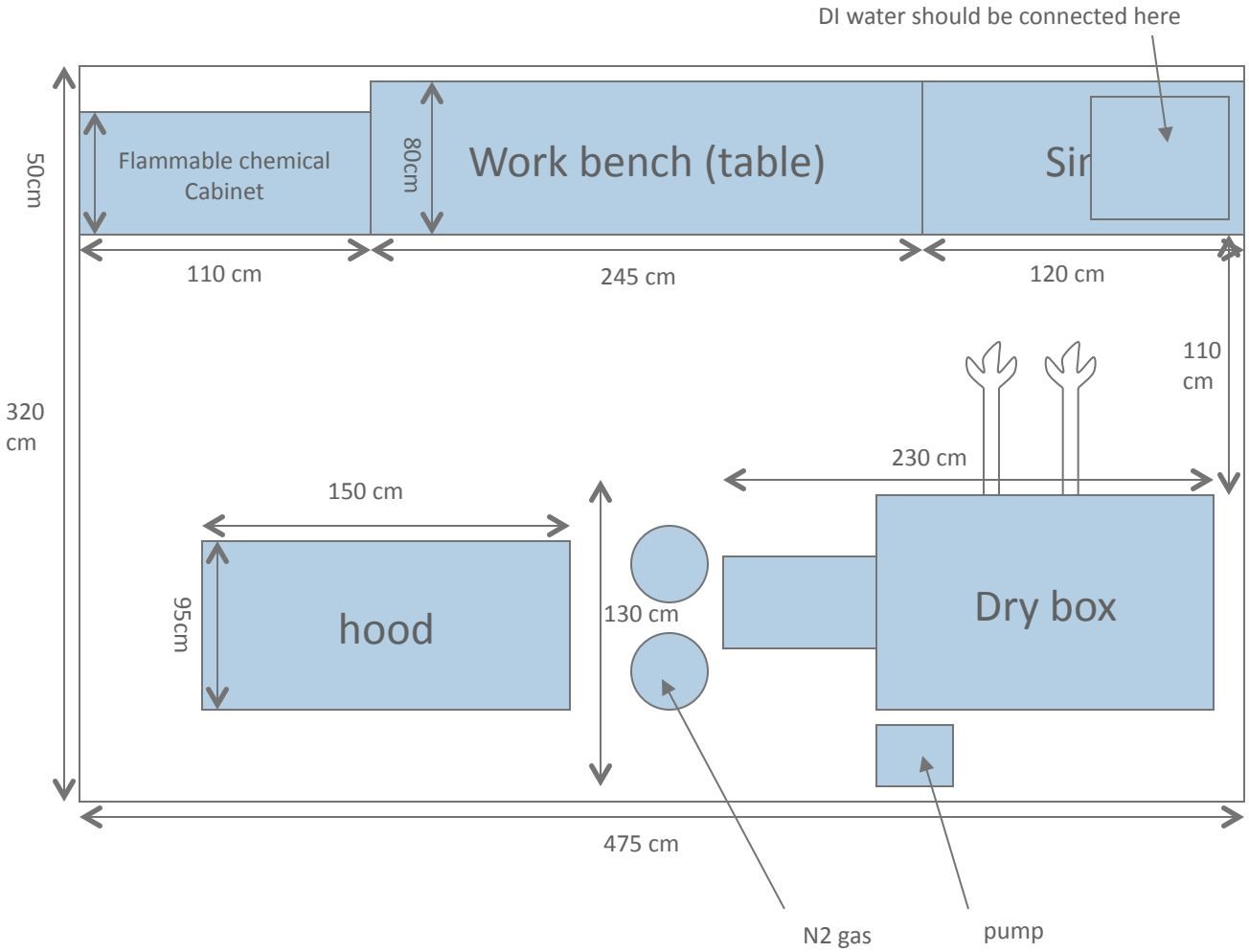
What is it What We Have To Measure GaAs-based Cathodes

- The physics:
  - Substrate (ex-situ): surface morphology; fermi level; characterization of dopents
  - Cathode: surface morphology and chemical composition (in-situ), dopent concentration and distribution
  - Functionality: QE(E), time response, momentum response
- The method:
  - Substrate: ex-situ STM/AFM, TEM/SEM?, XPS/UPS, UV-Vis spectroscopy, conductivity measurements
  - Cathode: CTR/XRD to characterize surface structure (APS), XAFS to characterize Cs-GaAs-O bonds (APS), AFM/STM surface composition/island formation, XPS/UPS chemical composition and electronic levels (complementary to X-ray work)
  - Functionality: High intensity 3 wavelength QE measurement (fast detection); wavelength dependent QE measurement (monochromator); Matth's laser-experiment; APRES in collaboration with Kathy

What is the Growth and Activation Facility

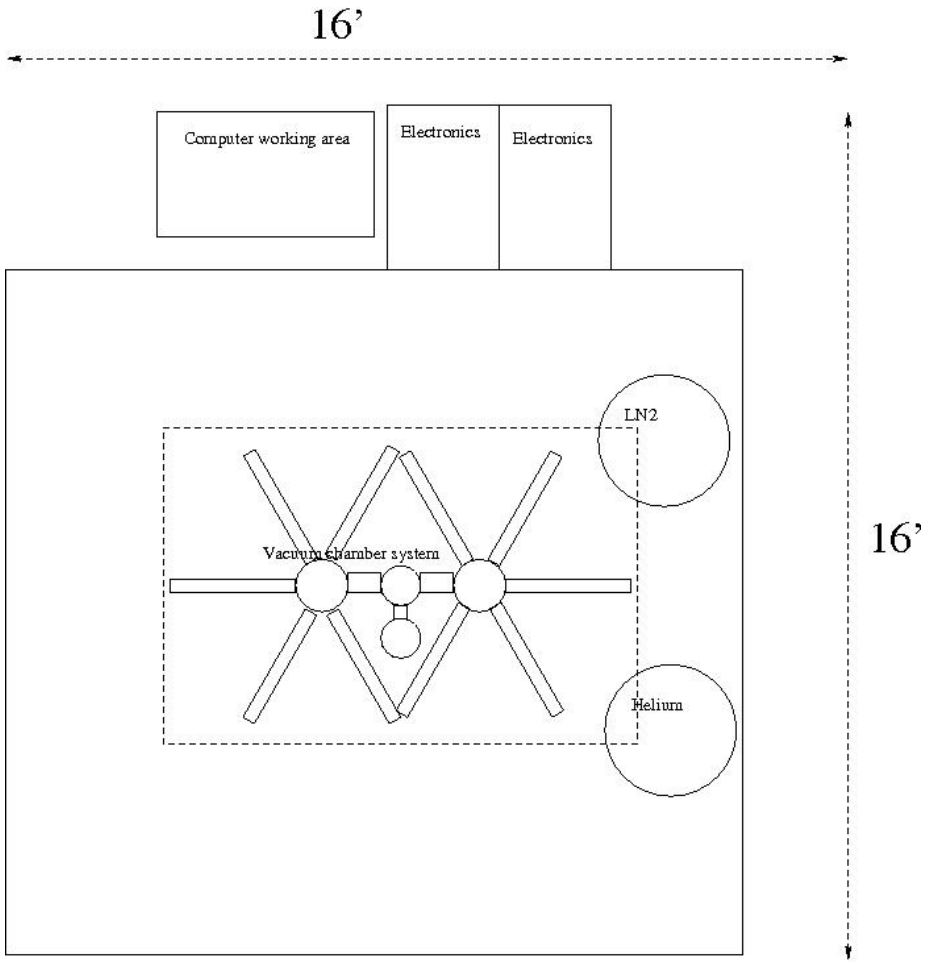
- The components:
  - Wet chemistry
  - The growth facility with QE characterization and in situ tools
  - The APS in-situ chamber and parts
  - The ex-situ characterization
- The role of the proposed laboratory:
  - Development of growth and handling protocols
  - QE measurements
  - In-situ measurements (LEED, $$STM/AFM$$, $$XPS/UPS?$$)
  - Host/test/service place for “APS”-equipment
  - Quality assurance for production

The Wet Chemistry (shared with tile facility?



- Clean working necessary
- Controlled access
- Safety requirements

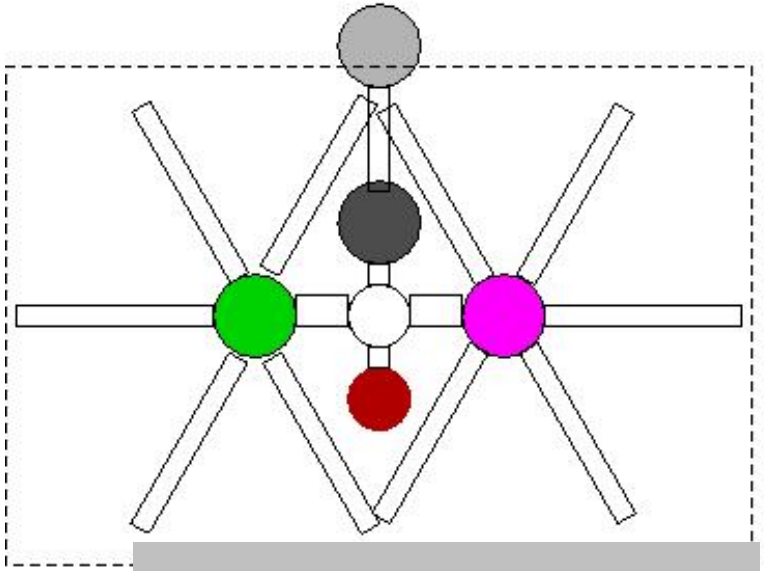
The Vacuum Facility



- Modular system which may grow with time
- Ex situ characterization: conductivity measurement, UV-Vis
- Next to the shown floor plan: work space for ex-situ characterization
- Glove box to handle materials and evaporators (8'x8')
- Additions equipment: evaporators for APS-MBE system and small growth chamber for bi-alkali
- Total requirements:
  - Space: 16'x20'-24'
  - Power: about 100A @ 110V (no 3 phase essential)
  - Pump exhaust system should be connected to vent system

Details on Vacuum Facility

Vacuum chamber system



GaAs

Bi–Alkali

Optional STM/AFM

Plasma Cleaning

Optional XPS/UPS