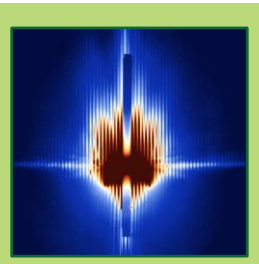
Center for Functional Nanomaterials

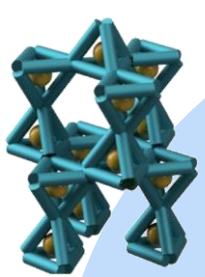
Charles (Chuck) Black, CFN Director

- Located at Brookhaven Lab, Upton NY
- Supporting 600+ users/year (2022)
- 300+ publications/year (~40% with IF>7)
- Co-located at BNL with NSLS-II

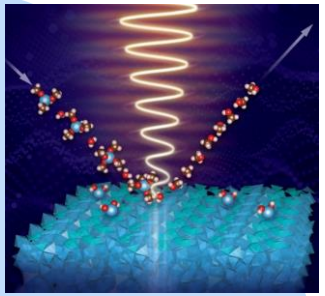


X-ray Nanoscience

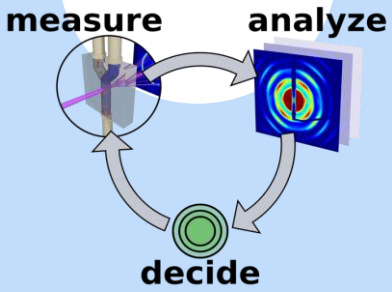
CFN strategic focus:



Nanomaterial Synthesis by Assembly



In-situ/Operando Science



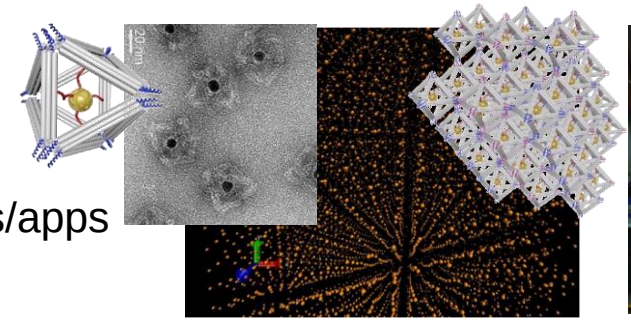
Accelerated Nanomaterial Discovery

“Top Three” CFN Science Impacts Aligned with DOE Priorities

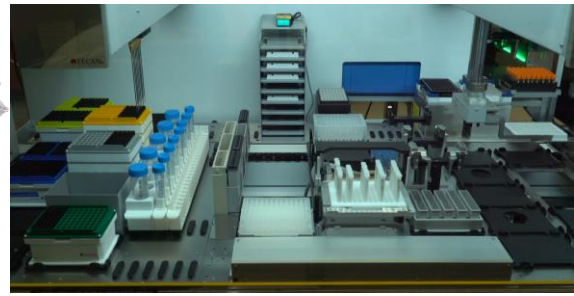
CFN staff research drives development of unique new facilities

DNA-mediated nanomaterial assembly

- DNA-programmable platform for synthesis of complex architectures by self-assembly of diverse nano-components
- **Since 2008**: 90+ pubs (15+ *Science, Nature Family)*; ~8 patents/apps
- Unique facility for automated DNA-programmable & large-scale material assembly, aimed at **transformative manufacturing**



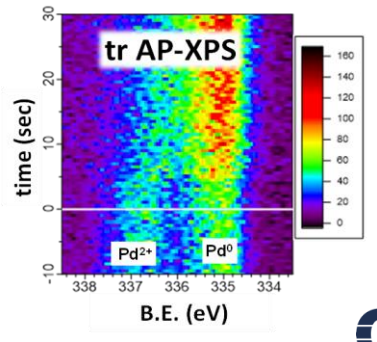
Science (2022)

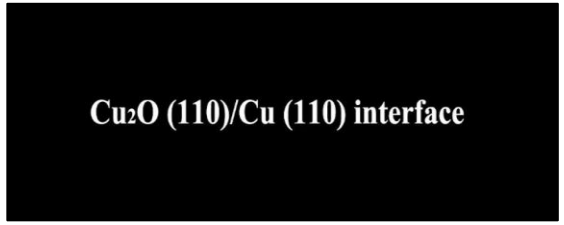


CFN facility for DNA-programmable material assembly

In-situ and *Operando* characterization with electron and X-ray probes

- Time-resolved imaging & spectroscopy of dynamic changes in local structure of **clean energy** materials under controlled environments
- **2022**: 83 users; 42 pubs (19 with IF>7)
- Multimodal integration of microscopy & X-ray spectroscopy

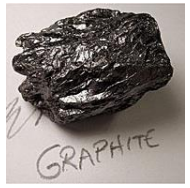




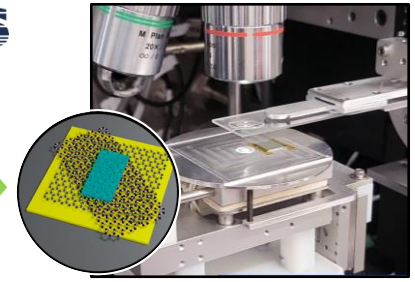
Nature (2022)

2D material synthesis, characterization, & assembly

- One of the first demonstrations of large-area graphene growth (*Nature Materials,* ~3000 citations).
- **2022:** 47 users; 13 pubs (7 with IF>7)
- Built the **QPress**: a unique facility for robotic assembly of stacked 2D material heterostructures for **QIS**



QPress



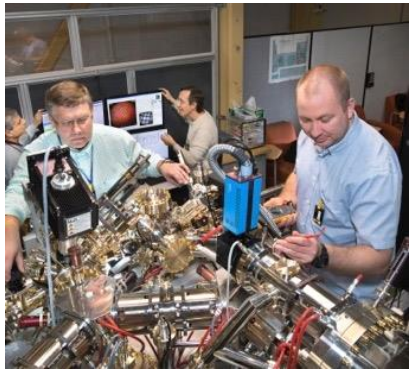
Nature Chem (2022)

Quantum Material Press

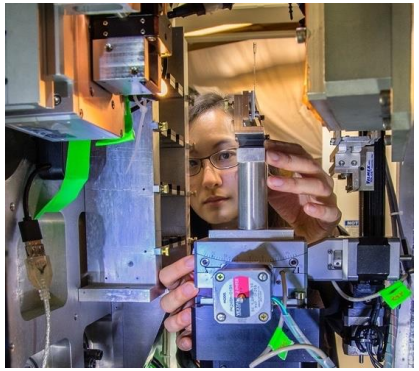
CFN Synergy with NSLS-II and the NSRCs

Since inception, CFN has had a foundational partnership with NSLS-II

- Jointly develop & operate 4 partner instruments
- **2022**: 146 unique users; 28 pubs (60% with IF>7)
- CFN operates complementary lab-based X-ray capabilities (XPEEM, SAXS, AP-XPS, & (future) X-ray tomography

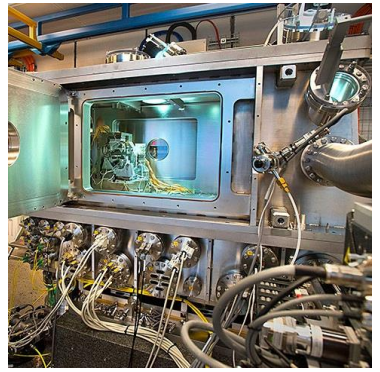


LEEM / X-PEEM



High-throughput exploratory SAXS/WAXS

High-flux resonant SAXS/WAXS



3D X-ray tomography (new 2023 partnership)

CFN leads the NSRC-Recapitalization Project team

- **NSRC-Recap Project**: Revitalize the US nanoscience infrastructure (17+ instruments)
- Team includes staff from all NSRCs
- Project is aligning new instrument locations with NSRC thematic focus

Other cross-NSRC interactions include:

- **AI/ML**
  - 4D Distillery (led by Foundry)
  - Digital Twin for Spatiotemporally Resolved Experiments (led by CNM)
- **Microelectronics Working Group** (led by CINT)

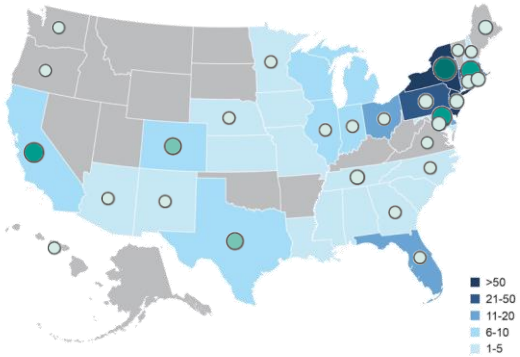
CFN User Community Strengths and Weaknesses

The CFN user community is highly productive, and carries out leading research resulting in high-impact publications

- Leading research institutions (e.g., Stony Brook, Columbia, NYU, Yale, MIT, Princeton)
- Supporting major DOE initiatives (EFRCs, C^2QA)
  - **2022**: 128 pubs in **Clean Energy**; 20 in **QIS**; 16 in **Microelectronics**
- Strong ties with Minority Serving Institutions
- Sizable community using both CFN and NSLS-II (236 users in 2022)

CFN has opportunities to expand the user community

- The CFN User community is predominantly regional
  - 62% of users from tri-state area (NY, NJ, CT) (includes BNL) (2022)
  - Remote user support is an opportunity to geographically expand
- Small community of industry users (~few %)
- Few users from DOE Labs (other than BNL)

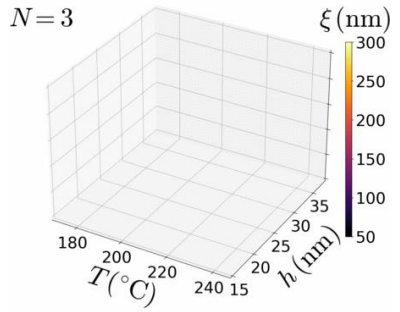


Remote operation of CFN TEM by the group of Prof. Dalice Piñero (Univ. Puerto Rico)

The Future CFN: Empowering the Next Generation of Materials Research

Autonomous methods are poised to transform materials science

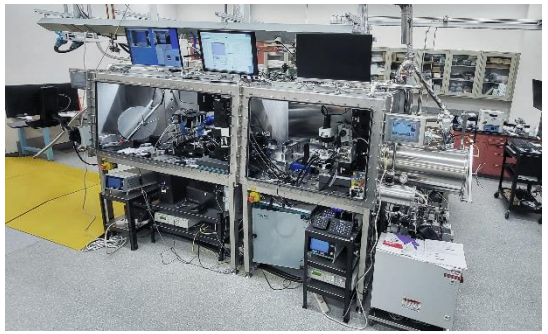
- Next-generation materials will require coordinated assemblies to achieve required performance
- AI/ML-driven experiments empower researchers to tackle more challenging problems
- The NSRCs are the right place to address the significant instrument and data challenges



Autonomous study of self-assembly

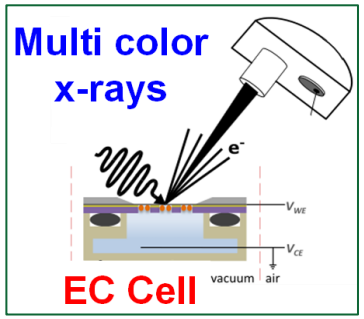
CFN will provide research and advanced capabilities aligned with national initiatives

QIS:



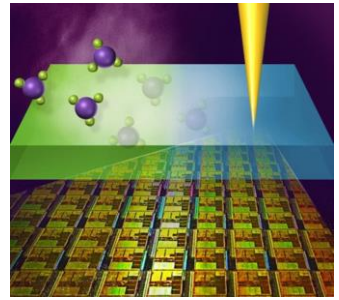
2D materials synthesis, assembly, & characterization

Clean Energy:



Planned AP-HAXPES and E-STEM for in-situ studies

Microelectronics:



CFN research on high-res Extreme UV photoresists

Opportunity: Link individual NSRC efforts by a common platform spanning across all Centers, for users to combine systems in their research