Vertically Aligned Carbon Nanotubes Embedded in Ceramic Matrices for Hot Electrode Applications

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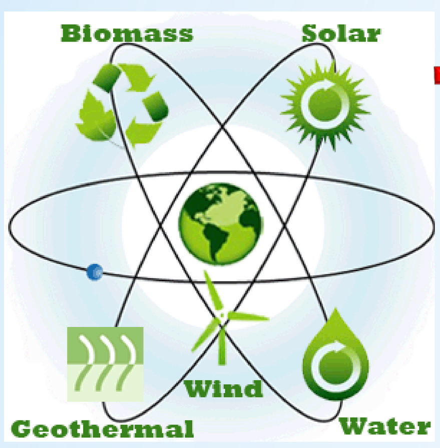
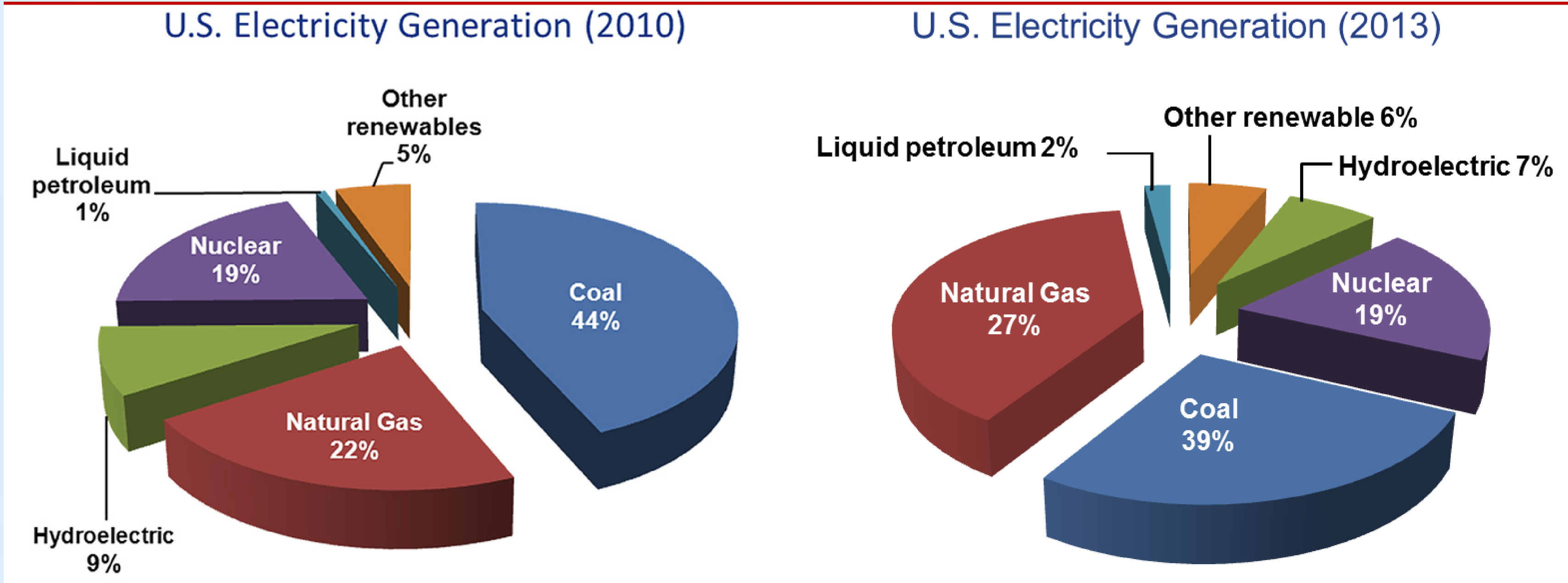
Challenges & Opportunities



New Energy Sources

High Energy Efficiency



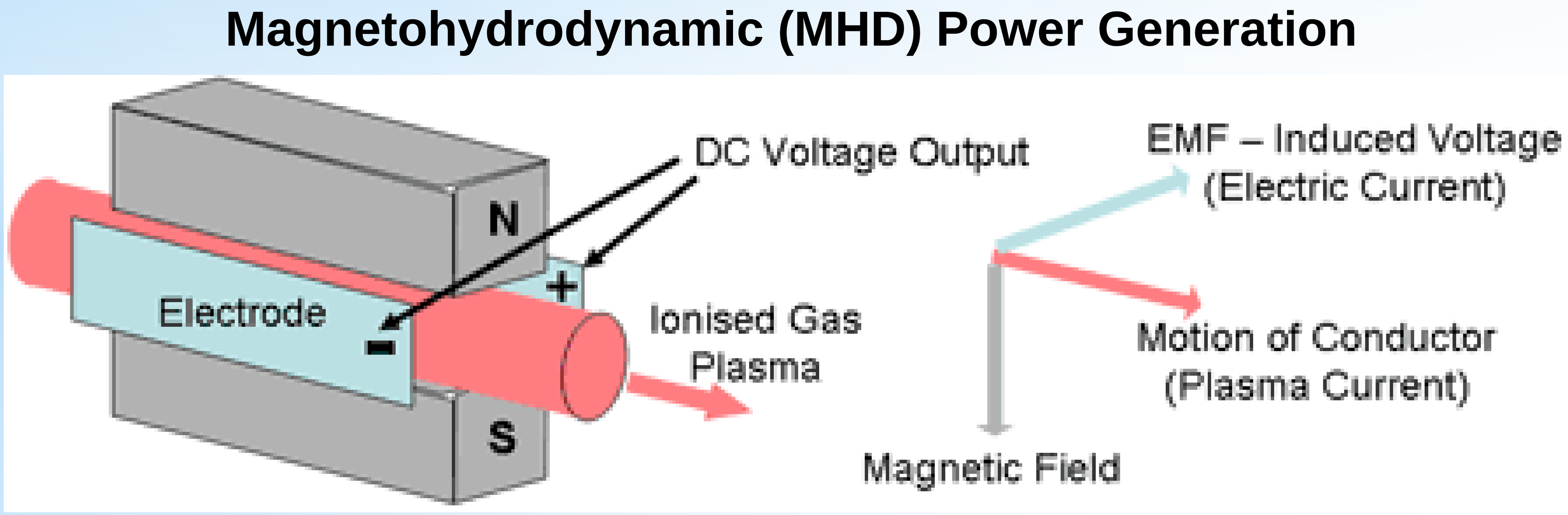
http://crf.sandia.gov/index.php/coal-use-and-carbon-capture-technologies/#.VBaDbvldV8E

http://www.eia.gov/tools/faqs/faq.cfm?id=427&t=3

Electricity Generation Efficiency

Method	Efficiency (%)	Ref.
Nuclear	33 – 36	Efficiency in Electricity Generation, EURELECTRIC "Preservation of Resources" Working Group's "Upstream" Sub-Group in collaboration with VGB, 2003
Coal	39 - 47	
Natural gas	< 39	
MHD	~ 65%	http://www.mpoweruk.com/mhd_generator.htm

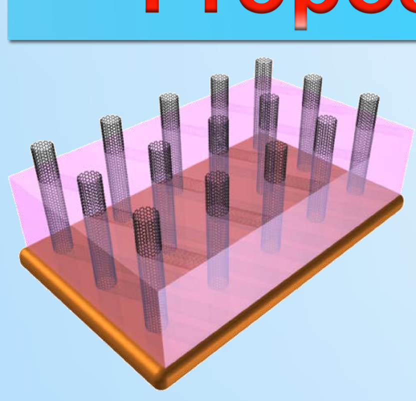
Magnetohydrodynamic (MHD) Power Generation



Materials Challenges of Magnetohydrodynamic Power Generator Electrodes

Requirement	Remarks
Electrical conductivity (σ)	σ > 1 S/m, flux ≈ 1 amp/cm^2
Thermal conductivity (k)	High heat flux from the combustion fluids at 2100 ˚C
Thermal stability	Melting point (T_m) above 2100 ˚C
Oxidation resistance	Resistant to an oxygen partial pressure about 10^{-2} atm at 2100 ˚C
Corrosion resistance	Potassium seeds and aluminosilicate slags
Erosion resistance	High velocity hot gases and particulates
Thermionic emission	The anode and cathode should be good acceptor and emitters.

Proposed Solution and Objectives



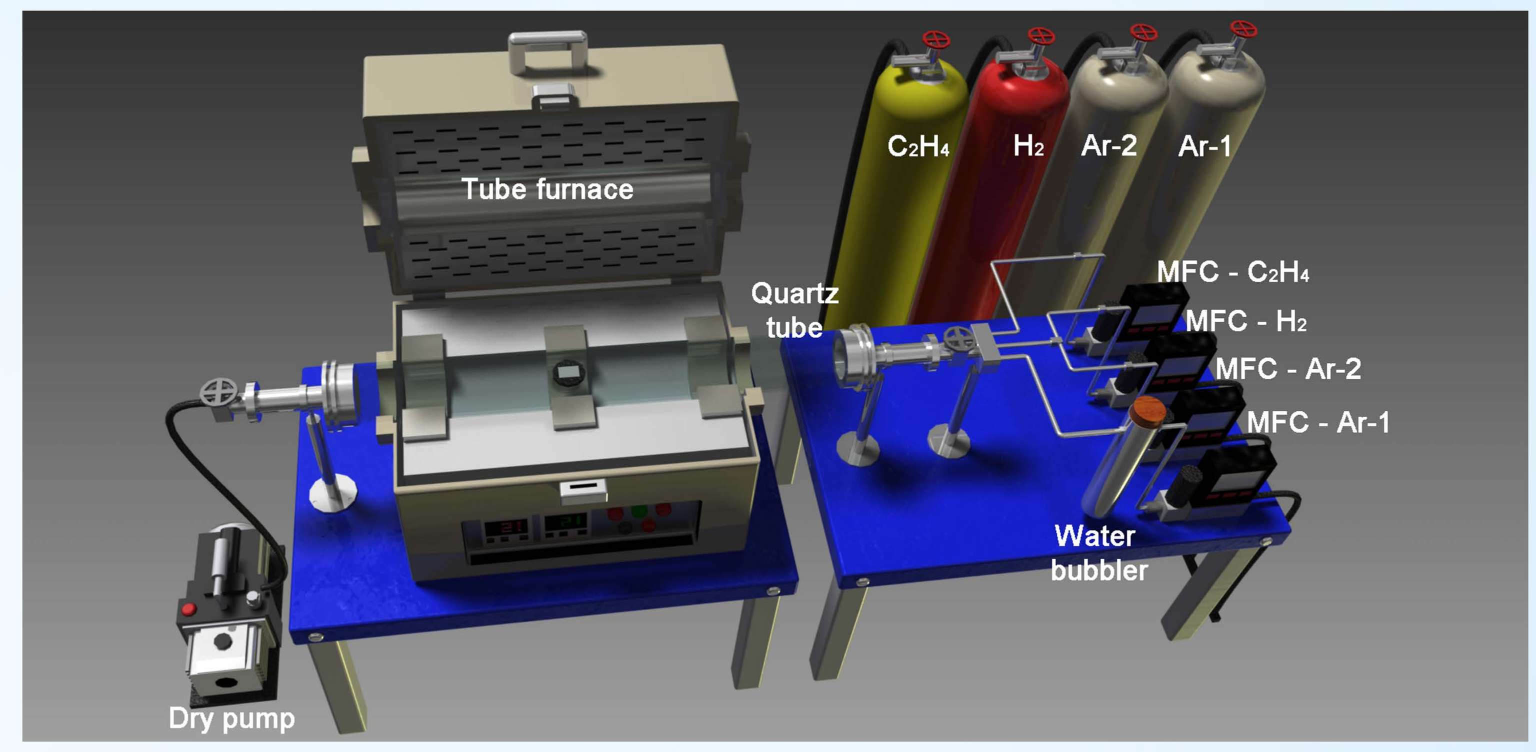
Property	c-BN	CNT
Melting point (˚C)	2973	> 1726
Chemical inertness	Inert to acids but soluble in alkaline molten salts and nitrides	Yes
Open air oxidation resistance (˚C)	1500	< 750
Electrochemical passiveness	Yes	Yes
Electrical conductivity (S/m)	Insulating	10^6 - 10^7
Thermal conductivity [W/(m·K)]	600 - 740	< 3000

- Vertically aligned carbon nanotubes (VA-CNTs): Electrical and thermal conductive channels.
- Cubic boron nitride (c-BN): Protective layer shielding CNTs from erosive and corrosive environments.

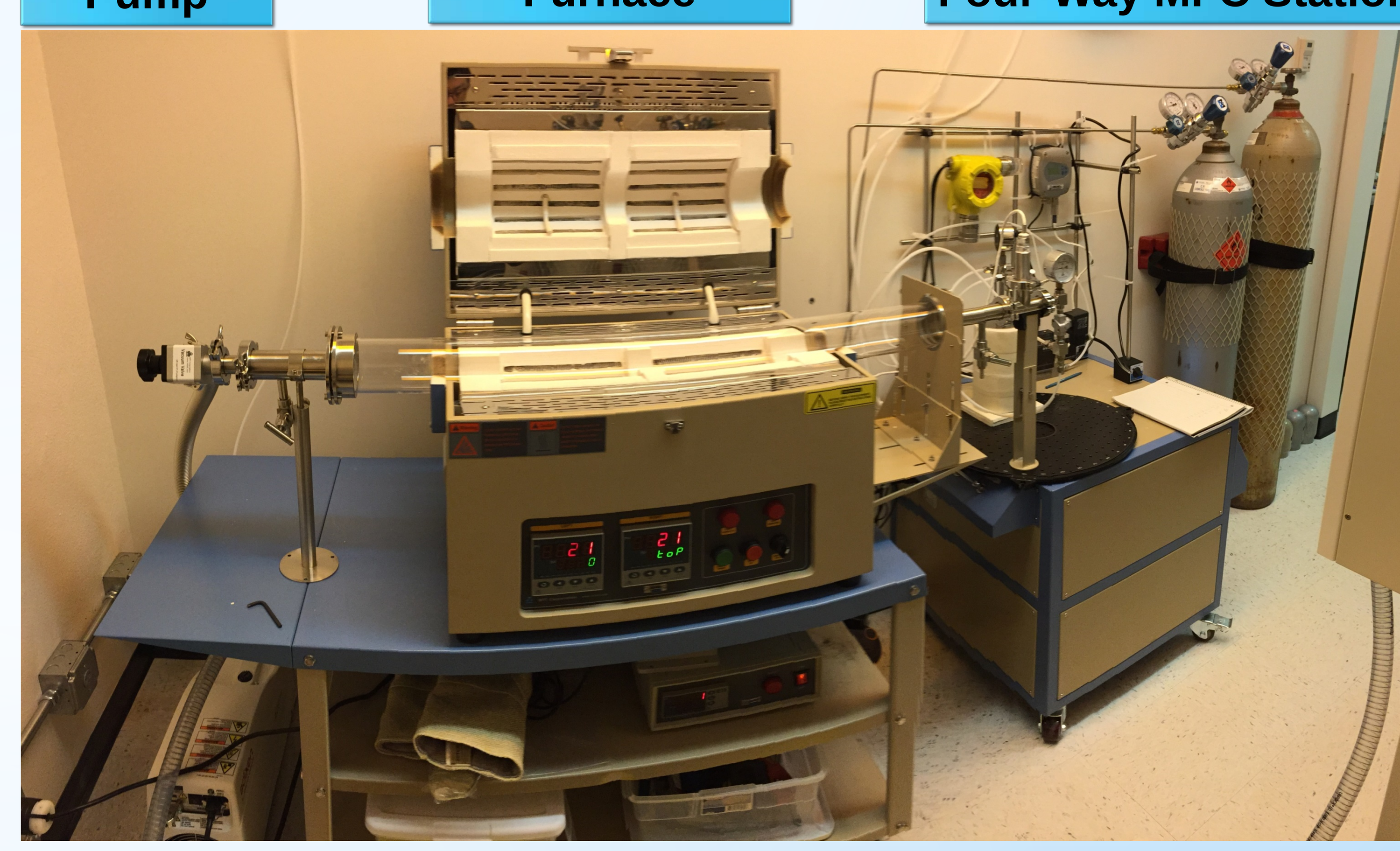
Objectives

1. Super growth of VA-CNT carpets on metallic substrates;
2. Fabrication of CNT-boron nitride (CNT-BN) composite structures;
3. Stability and resistance studies of the CNT-BN composite structures; and
4. Thermionic emission properties of the CNT-BN composite structures.

Current Progress

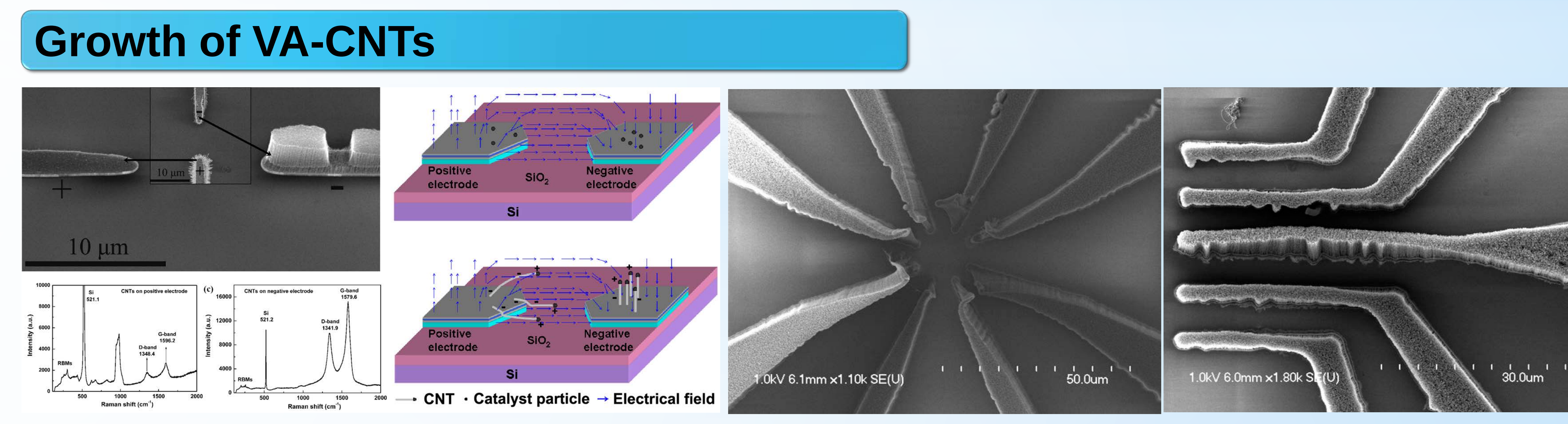


Dry Rotary Pump ← Two-Zone Tube Furnace ← Gas Cylinders and Four-Way MFC Station

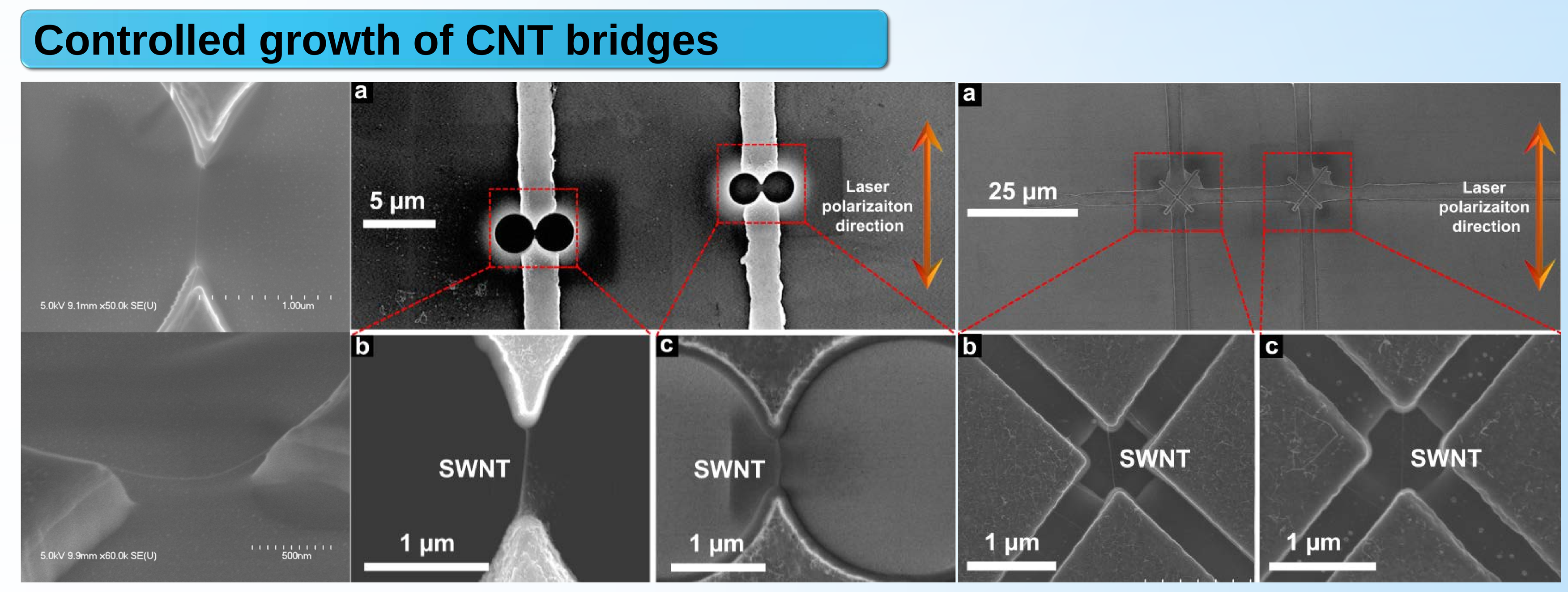


Preliminary Results

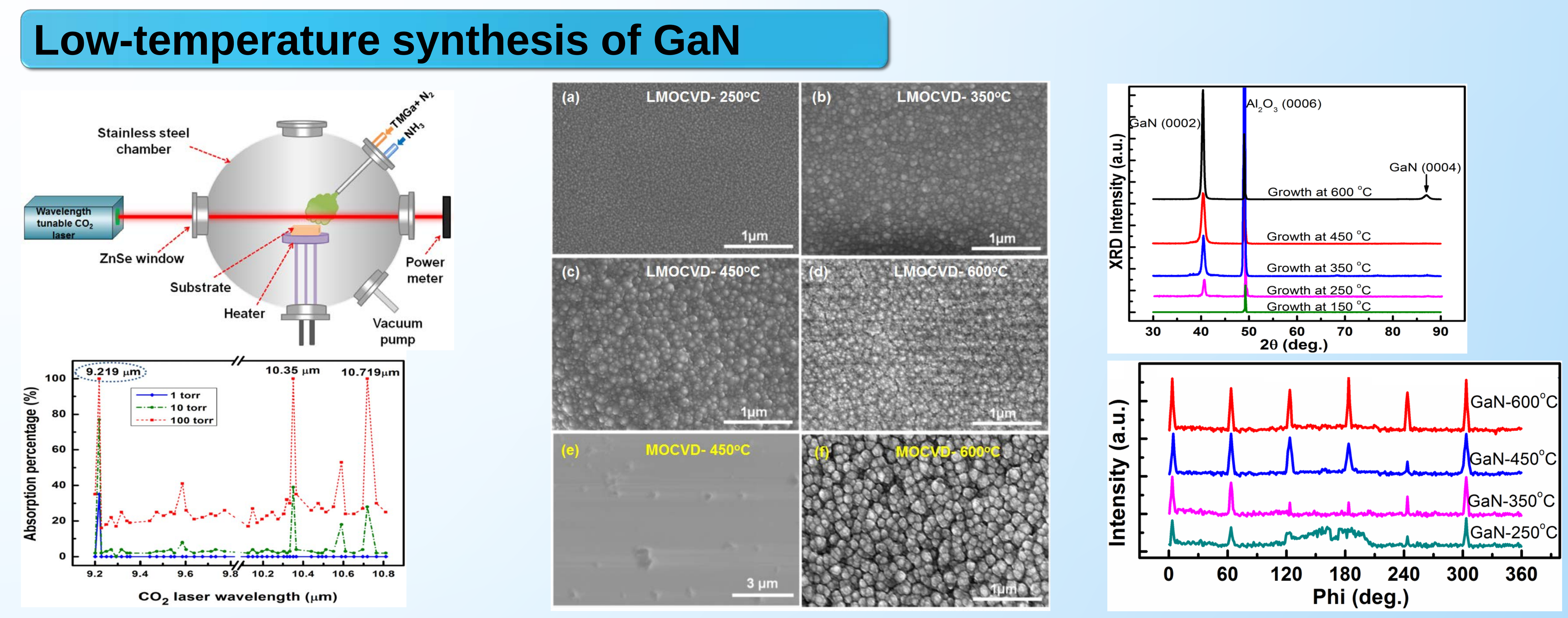
Growth of VA-CNTs



Controlled growth of CNT bridges



Low-temperature synthesis of GaN



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