

# CRN

## Clean Molecular Manufacturing

**“No Atom Left Behind”**

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# Today's dirty manufacturing

- Heavy metals
  - Extraction
  - Manufacturing
  - Disposal
- Processing
  - Coating
  - Trimming
- Imprecise chemistry
  - Sludge



# Mechanical Chemistry

~~FINGERS  
ATOMS~~

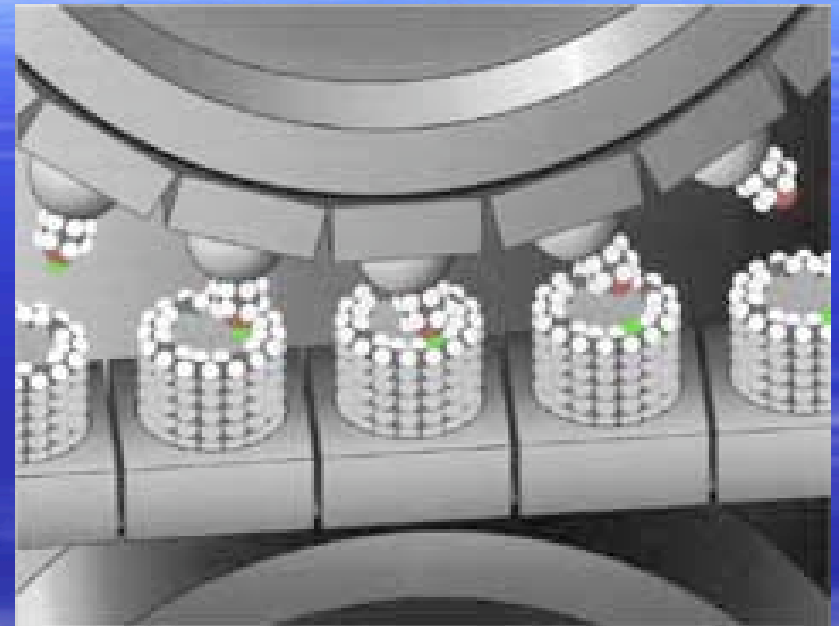
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# Mechanical Chemistry

- Transfer bound molecular fragments
- Hydrocarbon tool refreshing (Merkle, 1997)
- Need to build **product** with every atom
- Proposed bonds are all strong enough to survive at room temperature
- Reactions are digital, verifiable
- Room-temp atom removal has been done
- Mechanical force has been used to:
  - Remove a single silicon atom from a crystal
  - Replace it
  - Bond amino acids

# Molecular manufacturing

- Precise chemistry
  - Clean manufacturing
- Light elements
  - Locally available
  - Easy recycling
- High-performance products
  - Strength (1000x)
  - Computation density and efficiency (100,000x)
  - Power density (100,000x)



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# Molecular Mfg. Definition

- Programmable Chemistry
  - A few operations, repeated...
- Molecular Features
  - High performance
- Engineered Structures
  - Easy to design
- Reliable Operation
  - Allows automation
- Autoproductive Manufacture
  - Exponential manufacturing

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# Molecular Mfg. Performance

## ➤ Scaling Laws

- Power density ~ smallness
- Several kilowatts per cubic millimeter
- Feature density ~ smallness<sup>3</sup>
- Earth Simulator in a cubic millimeter

## ➤ Strength

- 100 times as strong as steel
- Another factor of 10 for compression->tension
- A 10-pound airplane, yacht, car...

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# Molecular Mfg. Scalability

- Scaling Laws, again
  - Operation speed ~ smallness
  - A million operations per second
  - A billion atoms ~ 1/5 micron cube
  - Could be built in ~1 hour by 1 billion-atom robot
- These systems, being reliable, could be run in parallel efficiently.
- A 10-pound factory, making its duplicate (or anything else) every day...

The logo for CRN (Chemical Robotics Network) features the letters 'CRN' in a bold, white, sans-serif font. The 'C' is slightly larger and positioned to the left of the 'R' and 'N'. Above the 'C' and 'R' are small, stylized representations of molecular structures or particles, consisting of small white dots and lines.

# Solving today's problems...

- Fossil fuels → Solar energy
- Dirty manufacturing → Replace it
- Inefficient infrastructure → Rebuild quickly
- Agriculture → Greenhouses
- Greenhouse gases → Collect them
- Other problems → Monitor them
- Small planet → Space access

# ...Creating tomorrow's problems

- Simple overuse
  - Terraforming
  - Heat pollution
- Weapons manufacture
- IP control
- Social and ethical issues
- Etc...

# Conclusion

- Molecular manufacturing can be as precise and elegant as digital logic.

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