World Energy Scheme for 30-60TW in 2050: The Distributed Store-Gen Grid

- Energy transported as electrical energy over wire, rather than by transport of mass (coal, oil, gas)
- Vast electrical power grid on continental scale interconnecting ~ 200 million asynchronous. “local” storage and generation sites, entire system continually innovated by free enterprise
- “Local” = house, block, community, business, town, …
- Local storage = batteries, flywheels, hydrogen, etc.
- Local generation = reverse of local storage + local solar and geo
- Local “buy low, sell high” to electrical power grid
- Local optimization of days of storage capacity & quality of local power
- Electrical grid does not need to be very reliable
- Mass Primary Power input to grid via HV DC transmission lines from existing plants plus remote (up to 2000 mile) sources on TW scale, including vast solar farms in deserts, wind, NIMBY nuclear, clean coal, stranded gas, wave, hydro, space-based solar (SPS and LPS)
- Hydrogen is transportation fuel

R. E. Smalley, Rice University

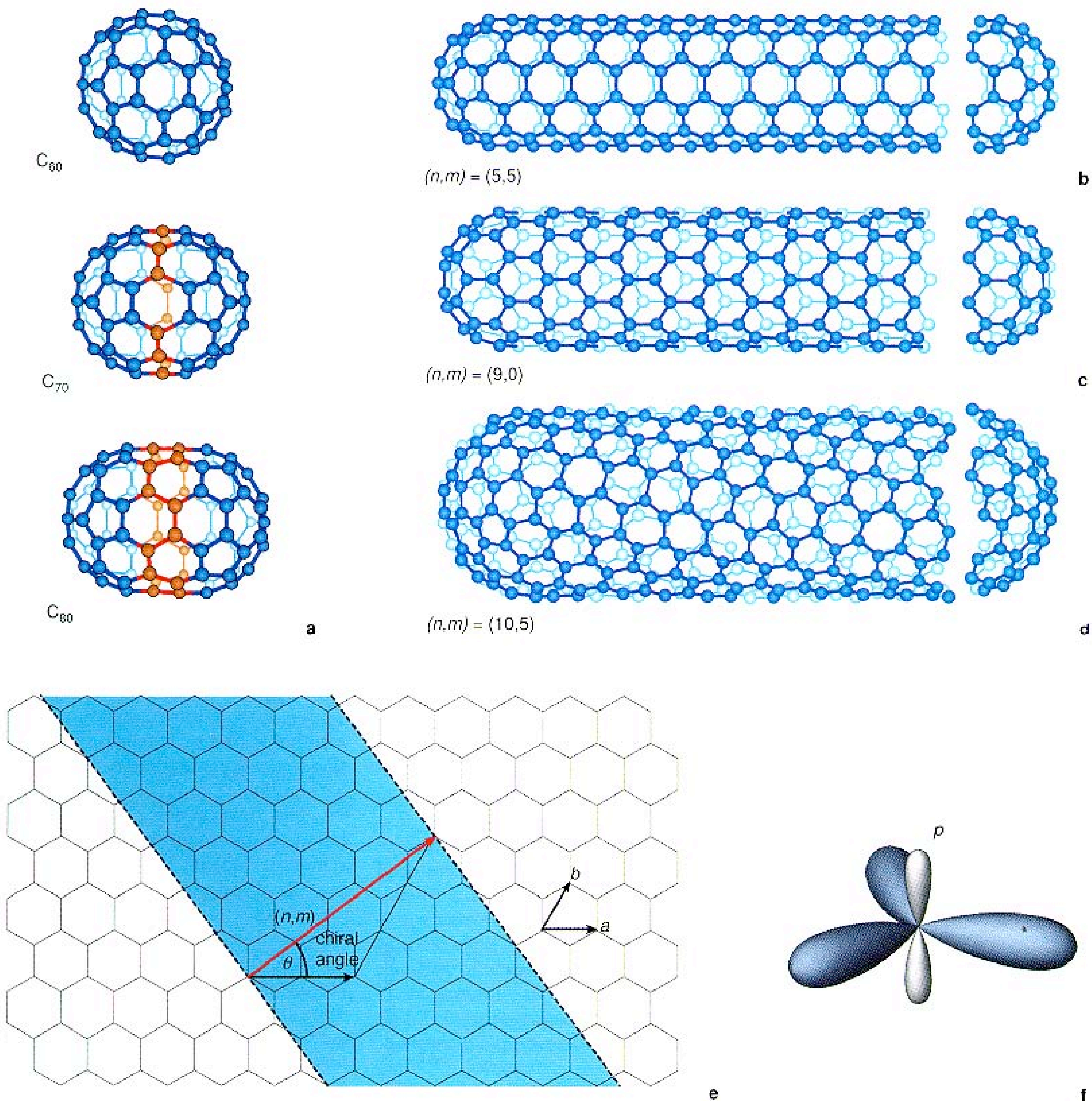
ARMCHAIR QUANTUM WIRE PROJECT

ELECTRICAL CONDUCTIVITY OF COPPER AT 1/6 THE WEIGHT WITH NEGLIGIBLE EDDY CURRENTS

- cut swnt to short lengths
- select out the (n,m) tubes with n=m (the “armchair tubes”)
- grow them to ~ 10 micron lengths
- spin them into continuous fibers

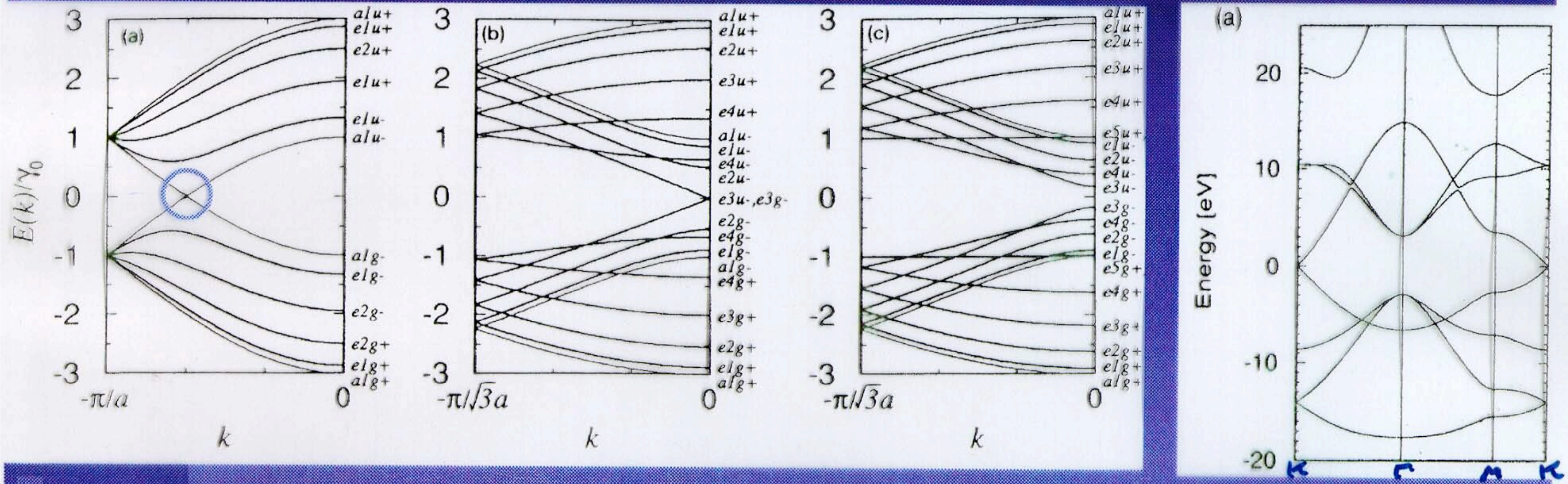
AGCI Aspen Workshop
July 9, 2003

R. E. Smalley, Rice University



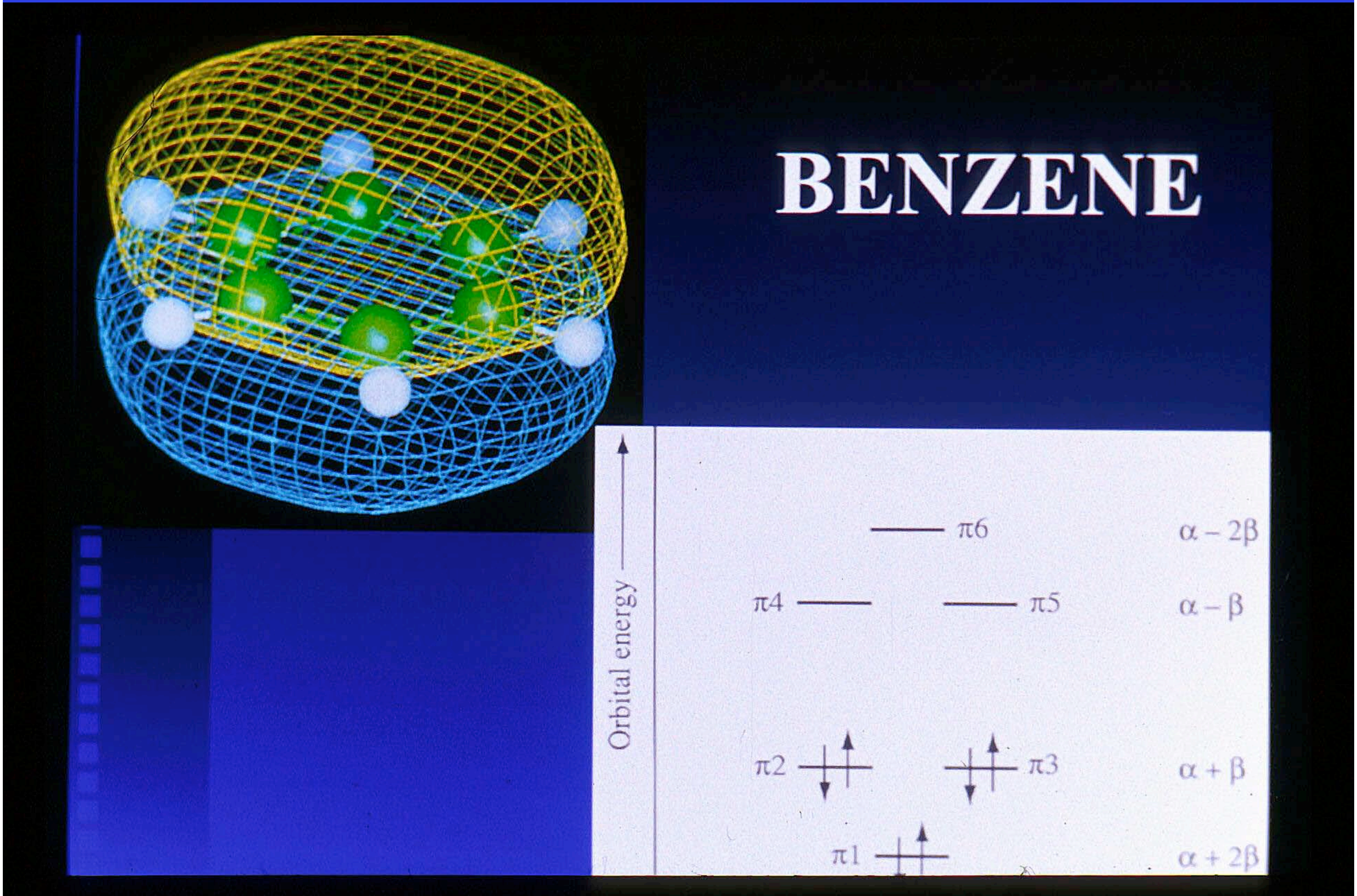
C60
C70
C60
a
(n,m) = (5,5)
b
(n,m) = (9,0)
c
(n,m) = (10,5)
d
(n,m)
chiral angle
θ
b
a
e
p
f

Band structures for various arrangements of graphene

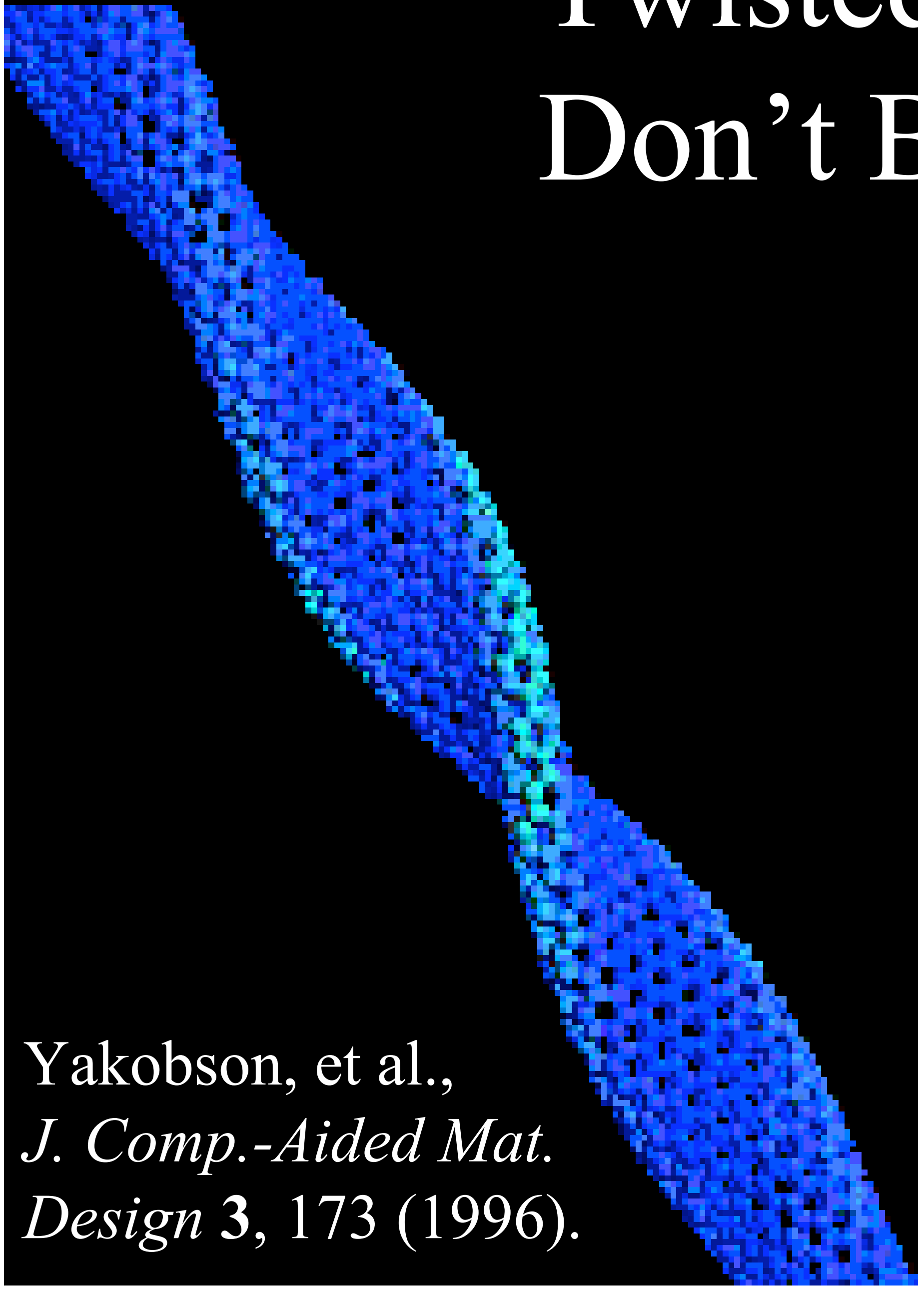


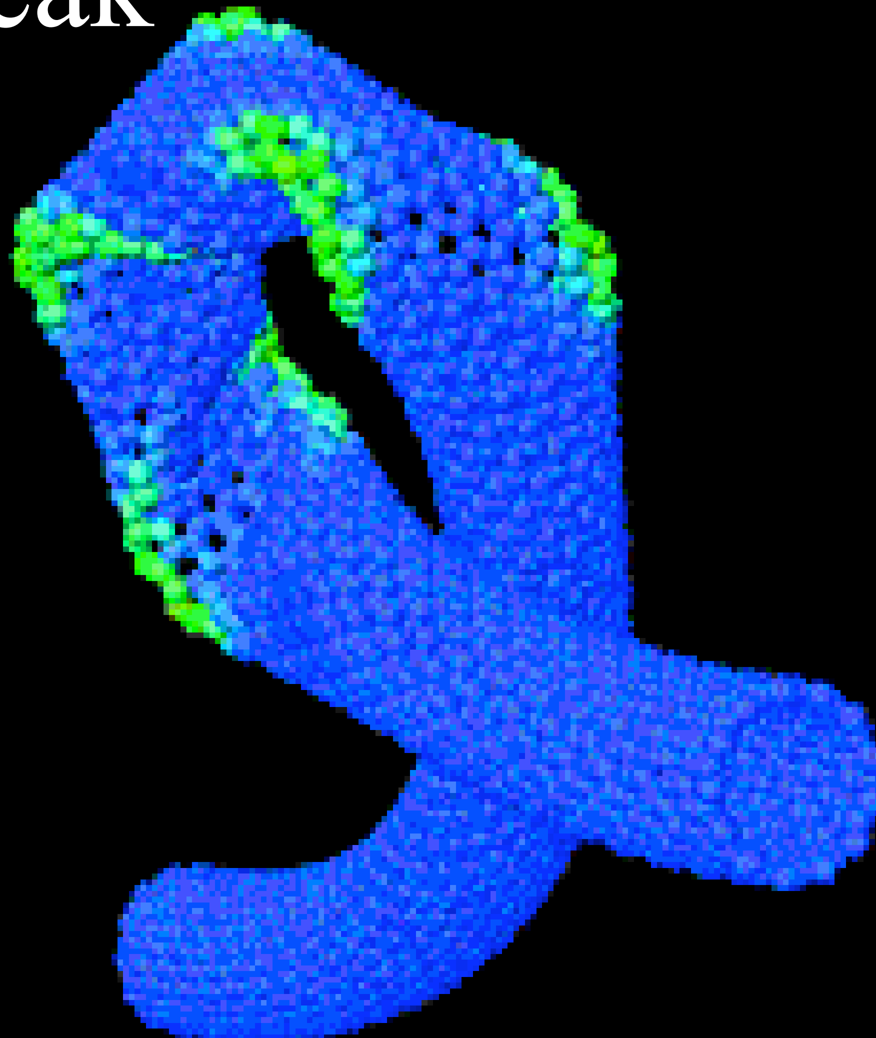
(5,5) tube (armchair) | (9,0) tube (zigzag) | (10,0) tube (zigzag) | planar graphene

M.S. Dresselhaus, G. Dresselhaus, P.C. Eklund, **Science of Fullerenes and Carbon Nanotubes**, Academic (1996).


BENZENE
Orbital energy
π6
α – 2β
π4
π5
α – β
π2
π3
α + β
π1
α + 2β

Twisted Tubes Don’t Break





Yakobson, et al.,
J. Comp.-Aided Mat. Design **3**, 173 (1996).


3 April 1997
International weekly journal of science
nature
Nanotube quantum wires
Enzymology Yeast 20S proteasome structure
Rock mechanics Stressed fractures
Vertebrate physiology Sustained energy budgets
New on the market
FASEB

An interesting feature of this junction is the sensitive dependence of conductance on the contact length, l. Figure 2 shows the conductance values for armchair-armchair and

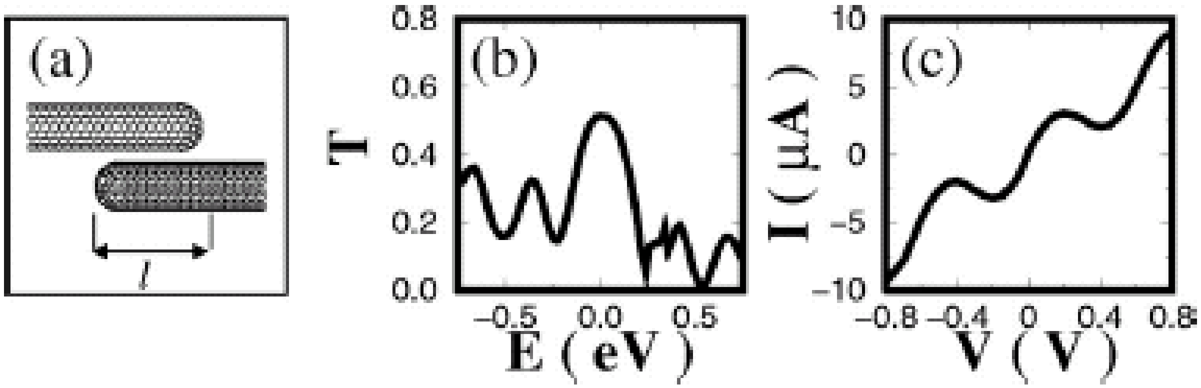
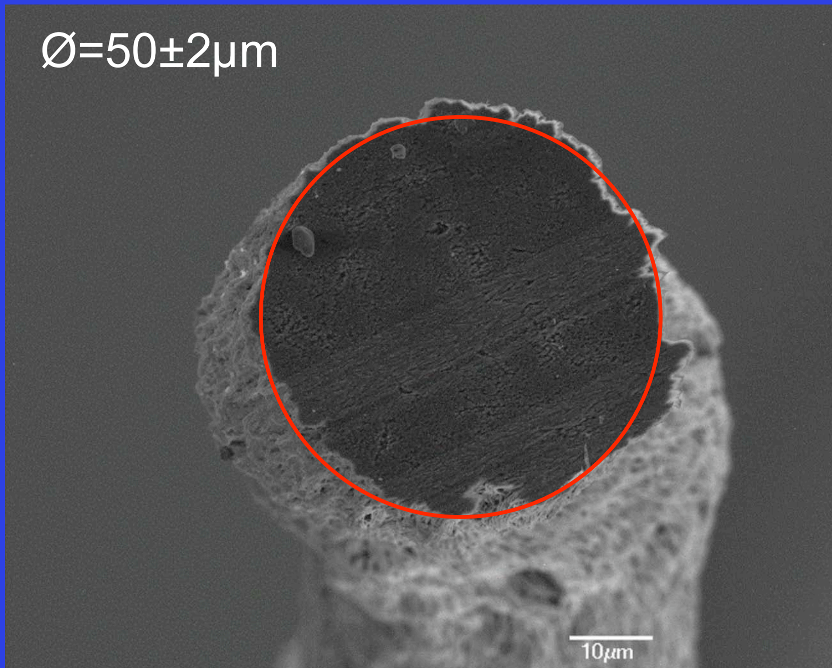
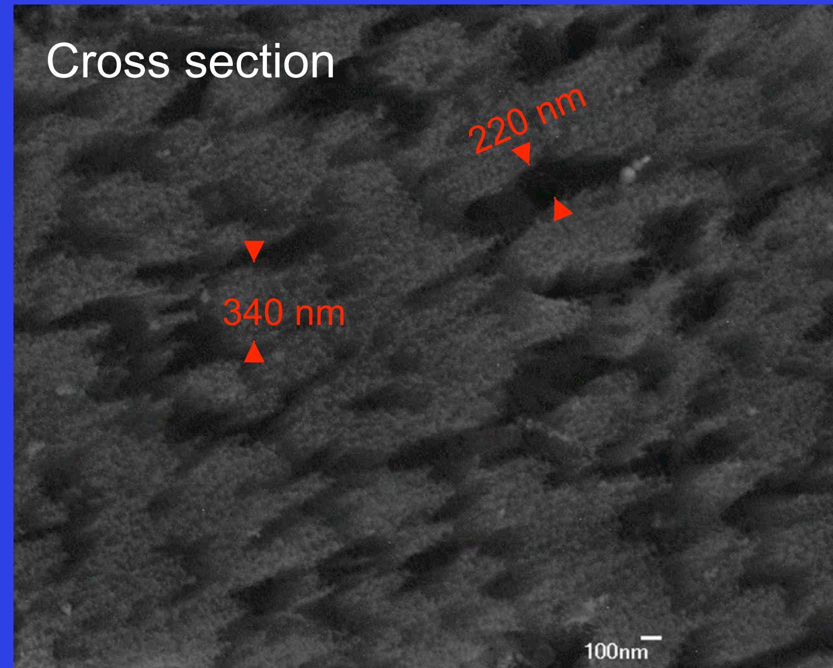


FIG. 1. (a) A two-terminal nanotube junction can be formed by bringing two tubes' ends together in parallel and pointing opposite directions (l is the contact length). (b) The transmission coefficient T of the two armchair tube [(10,10)-(10,10)] junction as a function of energy E for $l = 64$ Å. Interference of electron waves yields resonances in transport. (c) Current-voltage characteristics of the (10,10)-(10,10) junction for $l = 46$ Å.

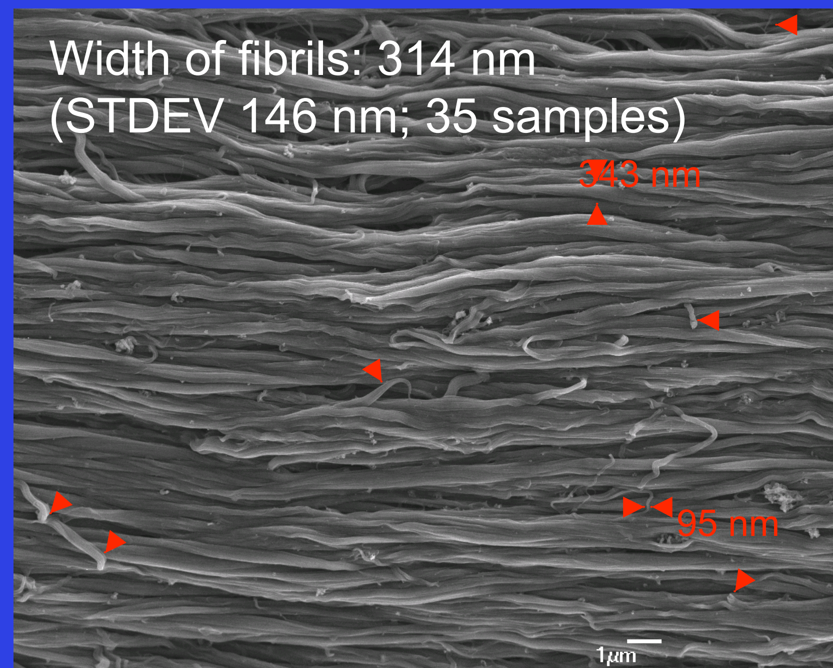
Alper Buldum and Jian Ping Lu, Phys. Rev. B 63, 161403 R (2001).

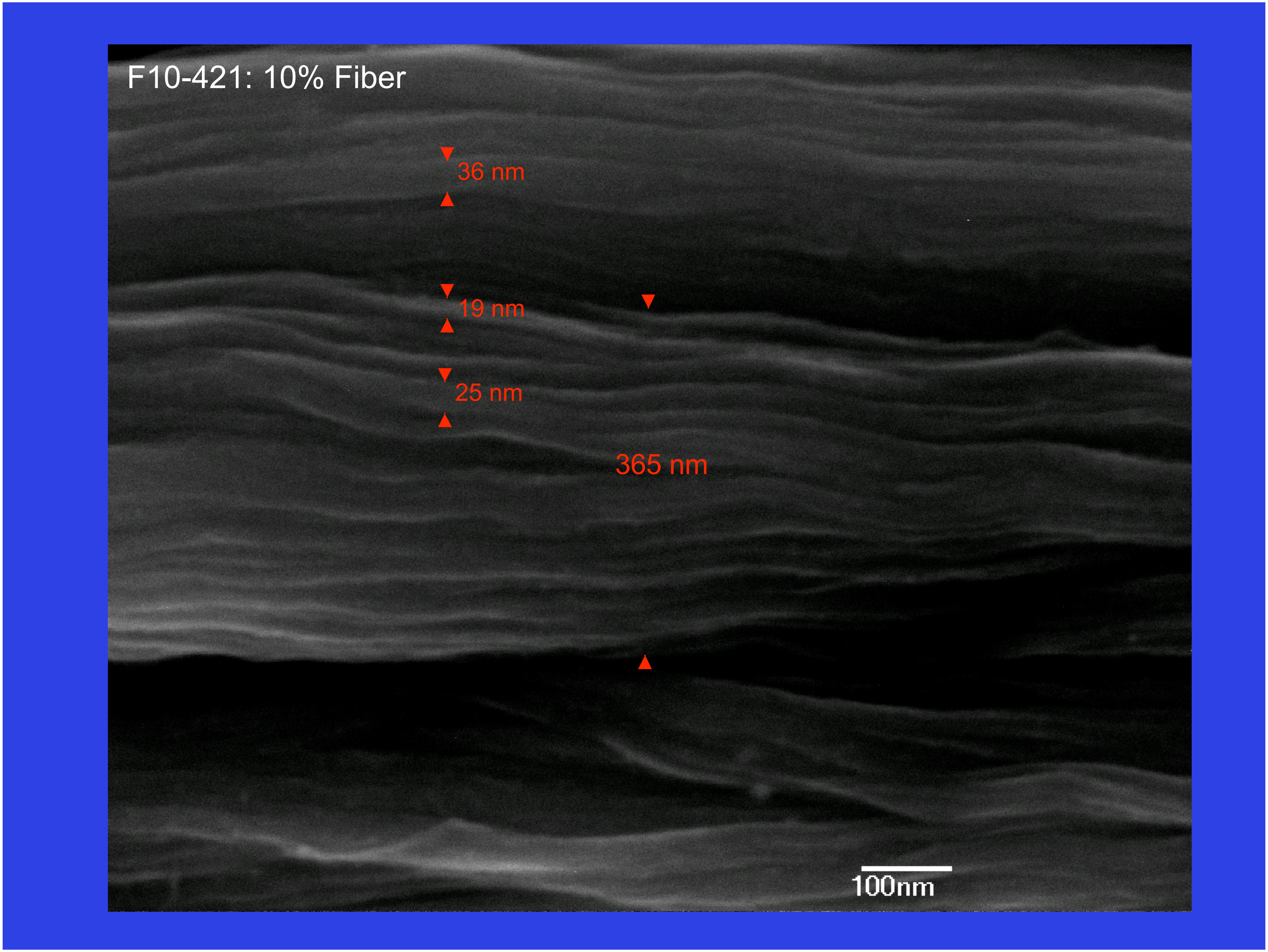




F10-421:
10% SWNT Neat Fiber
From 125 μm Needle Orifice

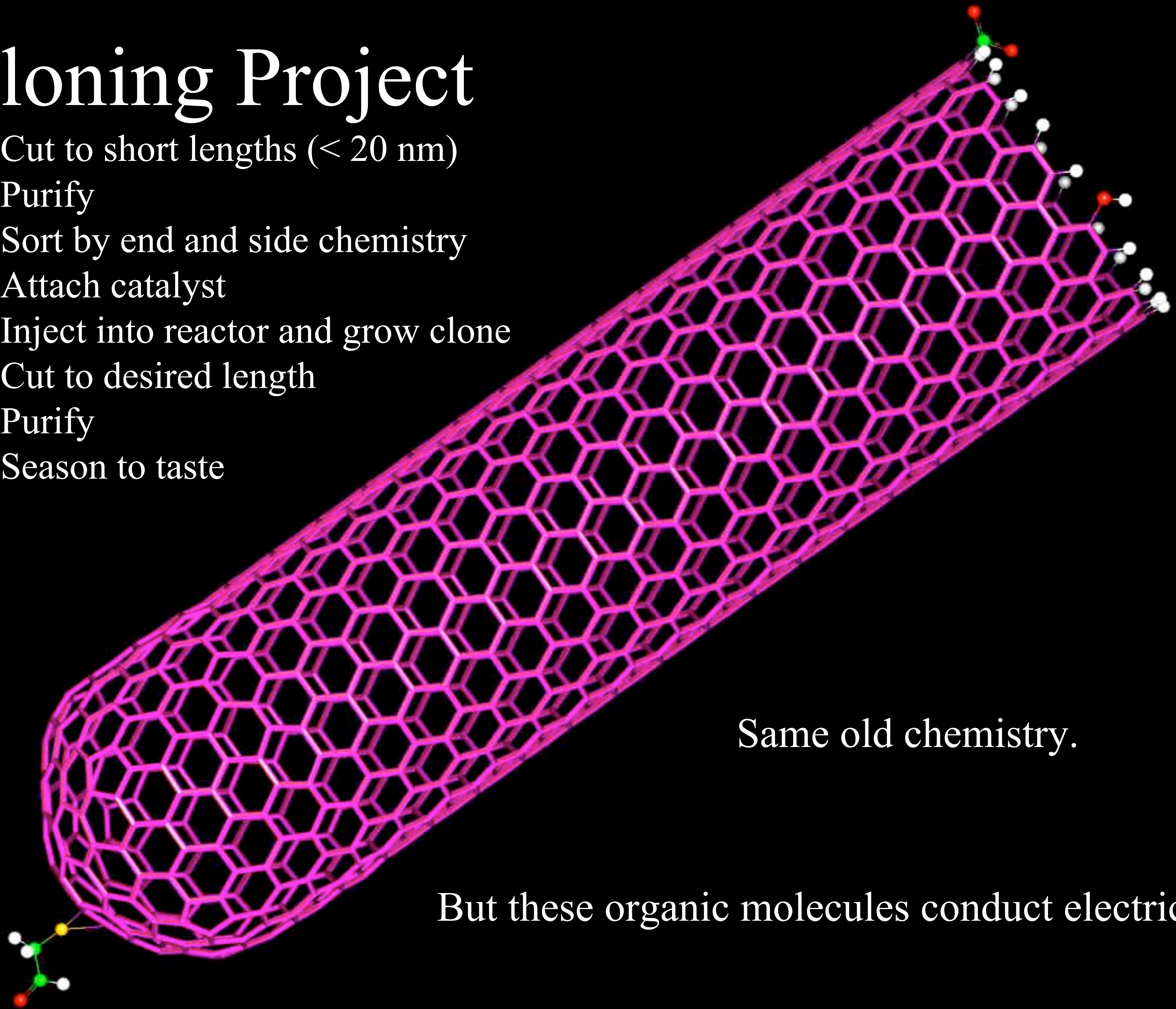
100%-13.2vol%/(50/125)^2
=19% void?




F10-421: 10% Fiber
36 nm
19 nm
25 nm
365 nm
100nm

Cloning Project

1. Cut to short lengths (< 20 nm)
2. Purify
3. Sort by end and side chemistry
4. Attach catalyst
5. Inject into reactor and grow clone
6. Cut to desired length
7. Purify
8. Season to taste



Same old chemistry.

But these organic molecules conduct electricity!

THE SWNT GRAND CHALLENGE

- Develop Methods to produce swnt with any single, selected n,m value
- In great purity, in large amounts, cheaply
- Understand their physics and chemistry both as individuals and arrays
- Learn to spin continuous fibers, membranes,composites, circuits, etc.
- Learn to grow to continuous single crystals

Reading Assignments

- 2002 State of the Future,
  (see www.stateofthefuture.org)
- The Hydrogen Economy, Jerry Rifkin
- Twenty Hydrogen Myths, Amory Lovins
  (see www.rmi.org)
- Hubbert's Peak, Kenneth Deffeyes
- The Prize, Daniel Yergin
- M.I. Hoffert et. al., *Science*, **2002**, 298, 981,