

# MMAT 2002- Basic Details

## Introduction to Structure, Properties, and Processing of Materials II

- Instructor: Prof. Bryan D. Huey
- Lecture Location: United Technologies Engineering Building, 175
- Lecture day/time: every T, Th, 11-12:15 am
- Final exam: May 8, 10:30-12:30 pm
  
- Office Hours: Wednesdays, 12:30-1:30
- Office Location: IMS Plaza Room 158 (Gant Bldg.)
  - Phone: 486 3284
  - Email: [bhuey@ims.uconn.edu](mailto:bhuey@ims.uconn.edu)
  
- TA:
  
- Textbook: Materials Science and Engineering: An Introduction  
By W. D. Callister Jr., **7<sup>th</sup> Edition**
- Some material will be uploaded to the course web site, reached from:  
<http://www.ims.uconn.edu/~bhuey/>



What were the most important inventions in the last 100 years?



- Materials to be covered this term
  - Ceramics
  - Glass
  - Polymers
  - Composites
  - Semiconductors
  - Superconductors
  - Dielectrics
  - Optical materials
  - Magnets
- Properties to be covered
  - Mechanical
  - Electronic
  - Optical
  - Thermal
  - Magnetic



# What is a Ceramic?

- Not a metal
- Not a polymer
- A semiconductor      Si, SiO<sub>x</sub>, GaAs
- A glass                      windows, fiber optics
- A toilet                      Alumina and other whitewares
- A plate                      porcelain
- A powder                    most common raw material
- A brilliant white additive in paint, laundry soap, toothpaste, or even oreos  
PbO, TiO<sub>2</sub>
- A dielectric                SiO<sub>x</sub>, TaO<sub>x</sub>, various titanates, PLZT
- A refractory                Alumina, calcia, silica
- An actuator/detector    PZT
- A superconductor        YBCO
- A surge protector        ZnO
- A high T component    SiN, SiC
- Any form of carbon      diamond, graphite, buckyball, nanotube
- A composite component    any of the above as particles, needles, sheets, or fibers (sometimes woven into mats).



# Ceramics and Glasses

8 Elements in Ceramics and Glasses

1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac															

57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr



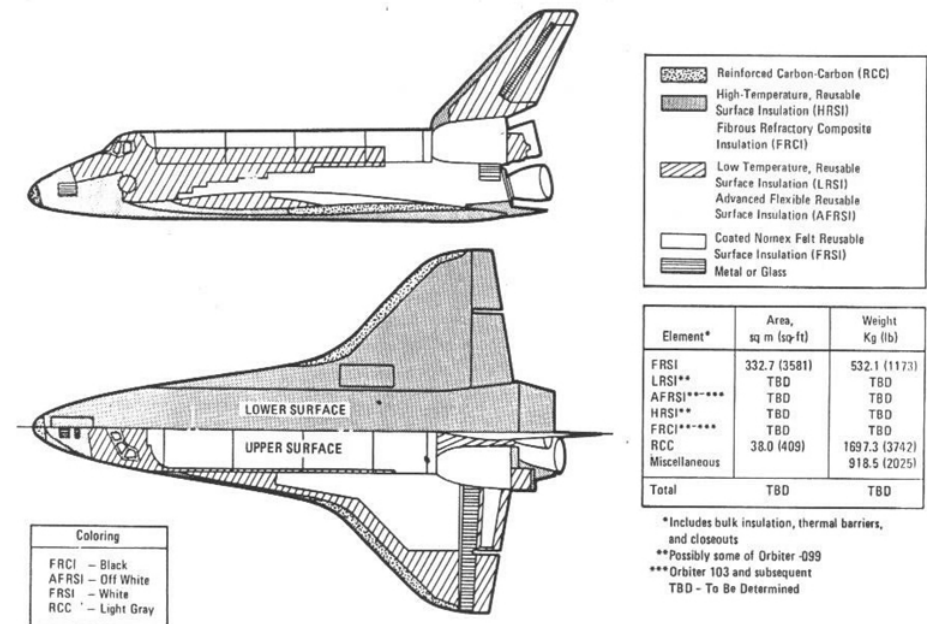
# Ceramics exhibit an astonishing range of properties

- Electrical conductivity (insulator to superconductor)
- Thermal conductivity (insulator to highly conducting)
- Magnetic properties (none, anti, ferro, para, super, giant, colossal)
- Dielectric response (1 to tens of thousands)
- Mechanical properties (aerogel to tank armor)
- Optical transmission (opaque to transparent)
- Colour (black to brilliant white)
- Form (powder, fiber, sheet, bulk, single crystal, polycrystal, amorphous)
- Multifunctionality (combination of the above)

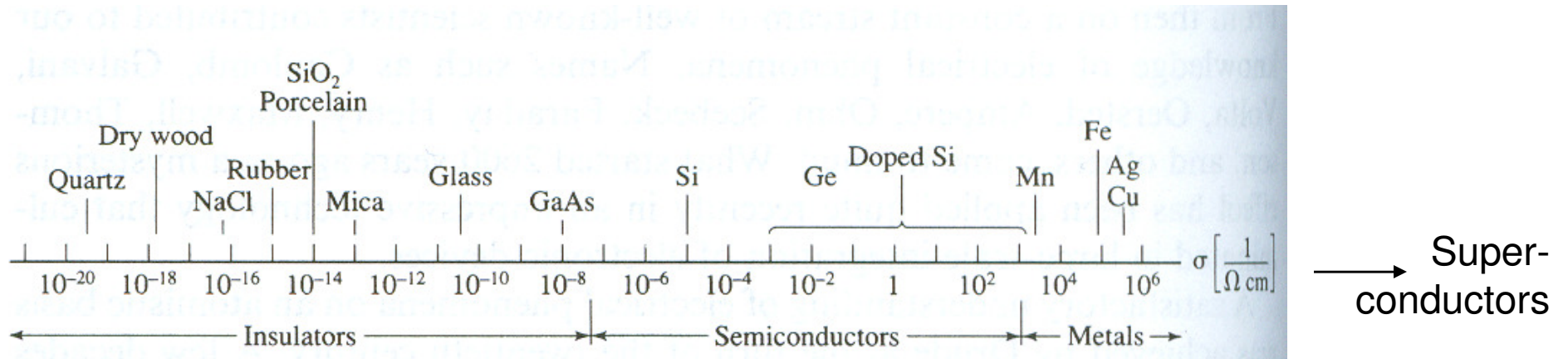


# Space shuttle thermal protection system

- The mechanical properties of the Al structure of the orbiter degrade beyond 175C, and the Al totally melts at 660C.
- The surface temperature will reach 1260C during descent.
- Solution: thermally insulating (but fragile) Silica tiles.



# CONDUCTIVITY: COMPARISON

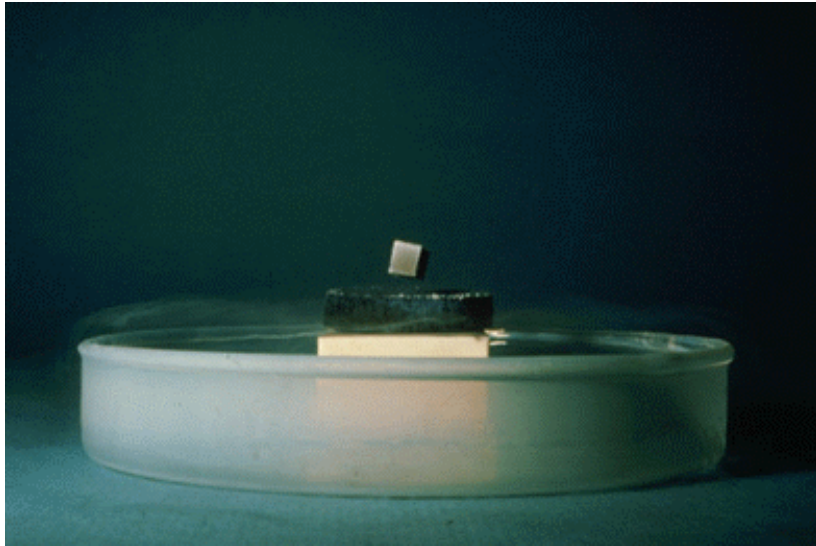


More than 30 orders of magnitude!



# Superconductors

A superconductor displaying the MEISSNER EFFECT



Superconductors have electronic and magnetic properties. Specifically, they exhibit a negative susceptibility, and acquire a polarization **OPPOSITE** to an applied magnetic field. This is the reason that superconducting materials and magnets repel one another (Meissner effect).

If the temperature increases the sample will lose its superconductivity and the magnet cannot float on the superconductor.

# Course Goals

- To provide a basic understanding of the structure and processing of:
  - powder, glass, semiconductor, optical, and composite ceramic materials.
- To relate mechanical, electronic, optical, magnetic, and thermal properties of these materials to”
  - defects, dopants, microstructure, and monetary and environmental cost-benefit analyses.

## Lectures

1. Collect homework (if due)
2. Objectives
3. New material
4. Summary
5. Reading for next class
6. Special instructions for next homework (if any)



# Grades

Assignments 40% total (5\*8% each)

Midterm 25% total

*(T. February 26, and Th. April 10, both in class)*

Comp. Final Exam 35%

*(May 8, 10:30 pm)*

term score	term grade	term score	term grade
>92	A	>72	C
>90	A-	>70	C-
>88	B+	>68	D+
>82	B	>62	D
>80	B-	>60	D-
>78	C+	<	F



# Policies and Procedures-Homework

- **All homeworks are due by the start of class (11 am) on the stated deadline.**
- **Late Policy:**
  - If you submit the assignment later on the due date instead (by 4:30 pm), you will lose 10%
  - if you submit the assignment 1 day late, you will lose 20%
  - if your assignment is even later *but* submitted before everyone else's is returned, you will lose 50%;
  - beyond that time you will earn no credit.
  - Late assignments go directly to my office/under the door.
- **If you wish, you may work together on homework assignments.**
  - Do not directly quote/copy other work (other books, web pages, etc).
  - Copied work is cheating—it is not permitted.
  - Those who rely on their peers for homework tend to suffer greatly on exams.



# Policies and Procedures-Other

- Midterms and Finals will draw heavily from homework assignments *and in-class discussions*.
- The exams are closed book and notes.
- BUT, you may have one side of one sheet of normal paper of notes written or sketched *in your own hand* for the exams.
- **Makeups for homeworks, midterms, and finals will be provided only for verifiable emergencies.** If this occurs, contact me by phone *and your academic advisor* as soon as possible.
- Partial credit for individual questions **will be given on midterm and final exams.**
- Partial credit for individual questions **will not be given on homework assignments.**



# Syllabus I

Date	Lecture	Topic	Reading	Remarks
1/20	1	Intro, Structures		
1/22	2	Ceramic Structures, planes	12.1-5	
1/27	3	Defects in Ceramics	12.1-5	
1/29	4	Mechanical Properties of Ceramics	8.4, 12.8-11	
2/3	5	Ceramics Phase Diagrams	12.6-7	HW1 due
2/5	6	Clay and powder processing, refractories	13.4-7, 13.10-11	
2/10	7	Glass and glass processing	13.1-3, 13.9	
2/12	8	Other ceramic processing		HW2 due
2/17	9	Polymer I	Ch 14	
2/19	10	Polymers II	Ch 15	
2/24	11	Composite Materials I	16.1-7	
2/26	12	Composite Materials II	16.8-15	HW3 due
3/3	13	Exam Review		
3/5		<b>Midterm Exam I</b>		MIDTERM
3/10		<b>No Class: Spring Break</b>		
3/12		<b>No Class: Spring Break</b>		
3/17		<b>No Class</b>		
3/19		<b>No Class</b>		



# Syllabus II

Date	Lecture	Topic	Reading	Remarks
3/10		<b>No Class: Spring Break</b>		
3/12		<b>No Class: Spring Break</b>		
3/17		<b>No Class</b>		
3/19		<b>No Class</b>		
3/24	14	Electronic Properties: metals	18.1-9	
3/26	15	Semiconductors	18.10-14	
3/28		<b>Emergency Snow Day</b>		
3/31	16	Doped Semiconductors	18.15	
4/2	17	Diodes and Transistors	18.16-23	
4/7	18	Dielectrics and ionic conductors	18.24-25	
4/9	19	Magnetic Properties I	20.1-20.6	HW 4 due
4/14	20	Magnetic Properties II, Superconductivity	20.7-12	
4/16	21	Thermal Properties	19.1-19.5	
4/21	22	Optical Properties I	21.1-7	
4/23	23	Optical Properties II	21.8-14	
4/28	24	Materials and Energy	???	HW 5due
4/30	25	Exam Review, Surveys		
???	<i>extra</i>	<i>Exam Review</i>		
5/8		<b>Final Exam, 10:30-12:30</b>	<b>Comprehensive</b>	FINAL



# Your Details

Please provide the following information on this page and hand it in at the end of class.

- Student Name:
- Peoplesoft Number:
- Photo number:
- Major or program:
- Year: (Sophomore, Junior, etc.):
- Email Address:

1. Please draw a BCC structure

2. Please draw a FCC structure

