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Your Name Goes On This Line

E106 Fourth Examination
30 April 2004
Suggested Exam Time: 50 minutes.
Long Question due on 1 May 2004
in Prof. Spjut's Office

In this examination you may use the class texts and *any notes* that you have taken in class or made in preparation for the exam. You may also use your homework and quizzes, and my homework solutions. *All other references are forbidden*. There are two sections to the exam. The first section consists of three short problems, each worth 16 points. They are designed to be answered quickly, without a great deal of derivation or calculation. To pass the class you must get two of the three essentially correct. The second section consists of one problems worth 52 points. The total possible for the exam is 100 points. Within each section, the problems are of equal weight but *not* of equal difficulty. There is partial credit. Please write neatly and *on one side* of your paper only. You may work on your problems in any order, but please assemble your completed exam with the problems in the correct order and in the correct section. For safety, you may want to write your name on every page.

Section I – Skills Questions (16 Points Each)

1. A platinum RTD ($\sigma = 9.43\times10^{6}(\Omega\text{m})^{-1}$) has a resistance of 100.0 Ω, and is constructed from a wire that is 8.322 m in length. What is the diameter of the wire?

2. An indium-doped sample of bavarium (a fictitious Group-IV semiconductor) has a conductivity at saturation of $106\ (\Omega\text{m})^{-1}$. The bavarium is doped with 1.0×10^{-7} atom-fraction indium. For bavarium $\mu_h = 0.21\ \text{m}^2/\text{V-s}$, $\mu_e = 0.45\ \text{m}^2/\text{V-s}$ and $\rho_{\text{Bv}} = 5.545\ \text{g/cm}^3$. What is the atomic weight of bavarium?

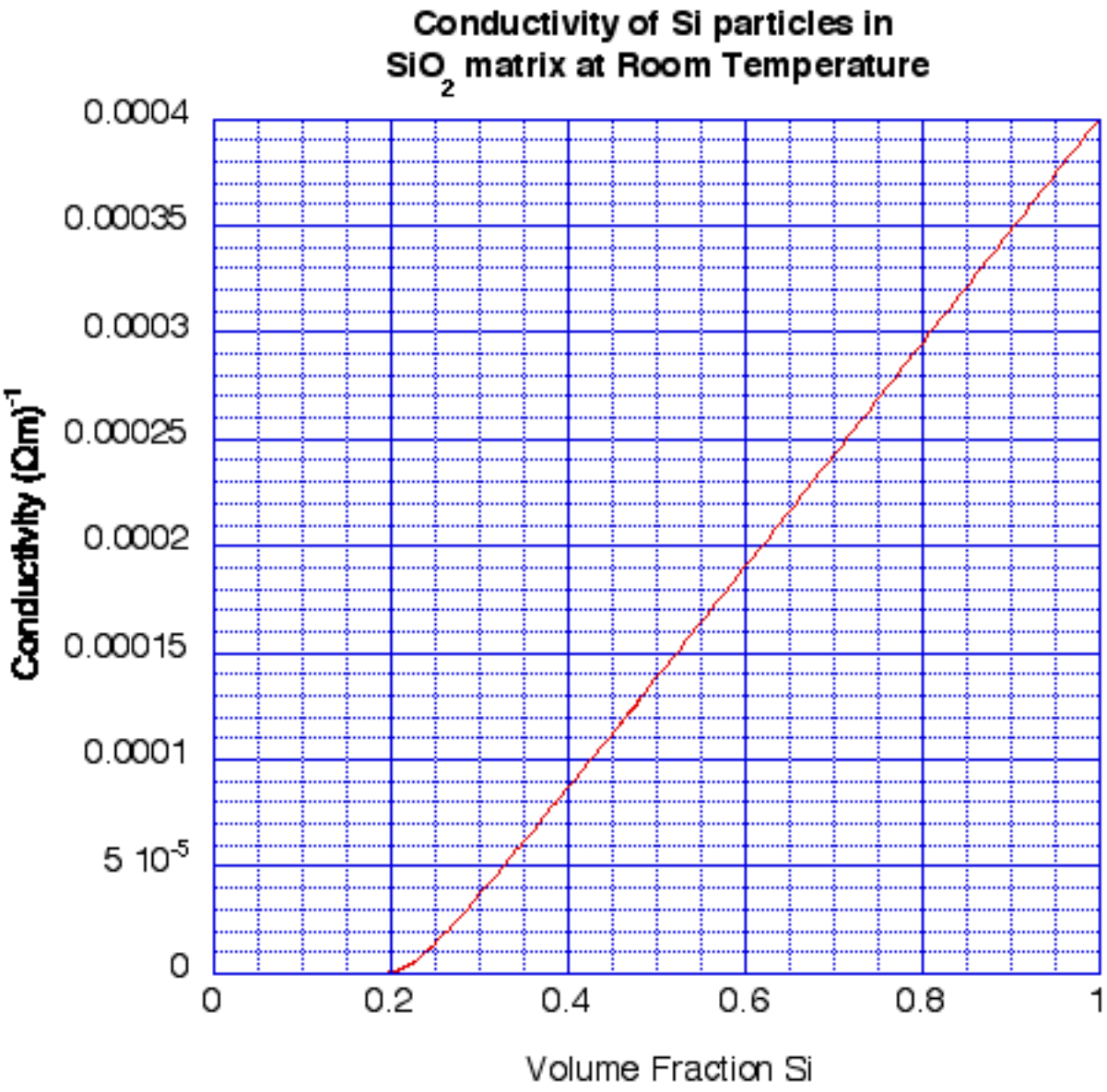
3. A cantilever beam is to be constructed from one of the materials in the table below. If the objective is to minimize mass and the constraint is the maximum load on the beam, which of the below materials is best?

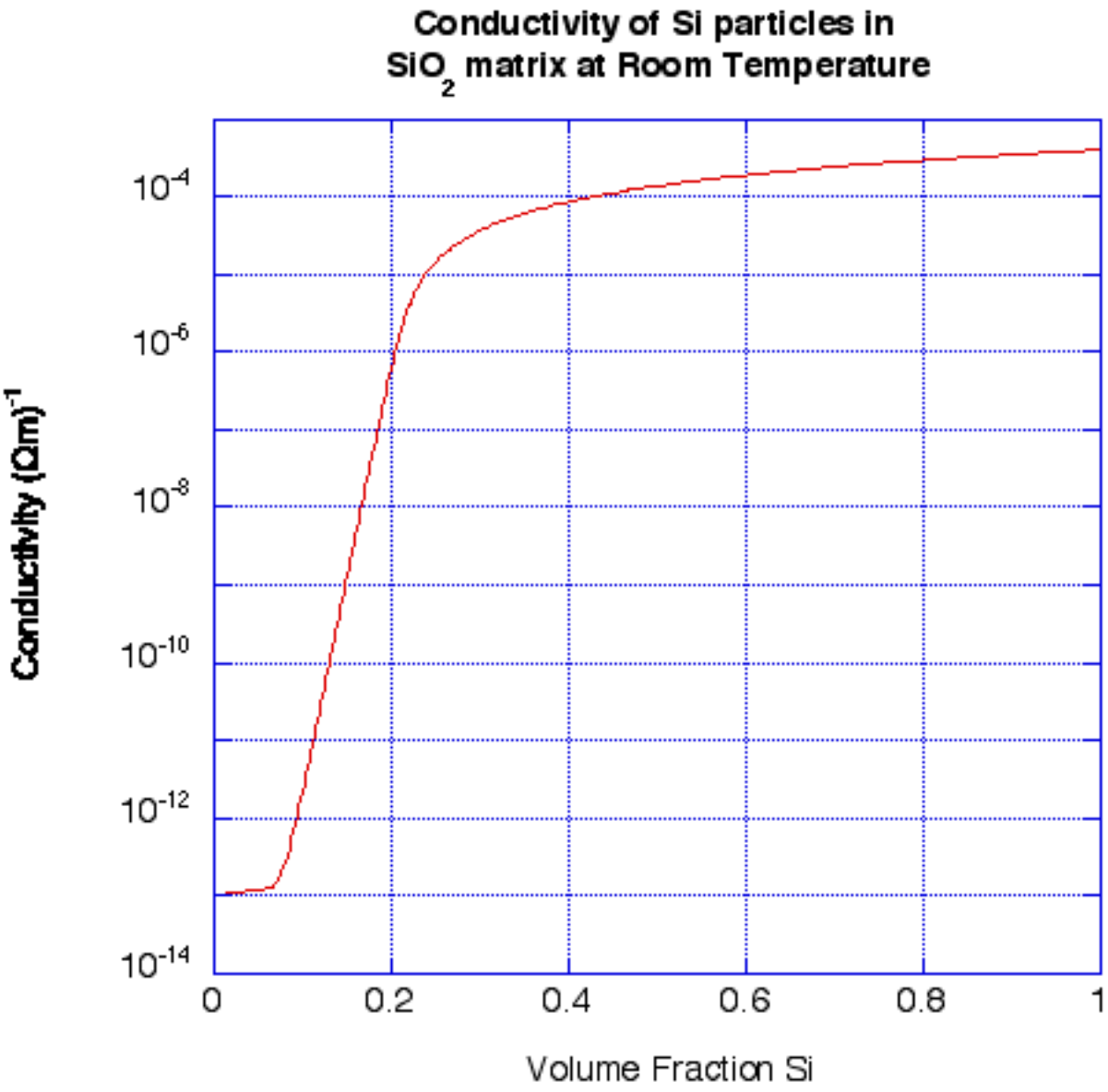
Table 1: Data for Problem #3

Material	E (GPa)	ν	YS (MPa)	TS (MPa)	ρ (g/cm^3)	K_{Ic}	C_p (J/kg K)
1040 steel	200	0.30	600	750	7.87	51	444
silicon nitride	304	0.24	N/A	1000	3.30	5	750
nyon 66	2.8	0.41	N/A	82.7	1.15	3	1670
Douglas fir	13.4	0.30	N/A	85.5	0.50	13	2900

Section II – Long Question (52 Points)

1. The (pseudo-)experimental results for measurement of the conductivity of a composite consisting of intrinsic silicon spheres in a fused silicon-dioxide matrix is shown below on both linear and semi-logarithmic scales.
   a) Sketch as accurately as possible the limiting cases on the graph with the linear scale.
   b) Explain the shape and unusual features of the graph. Be as quantitative as possible.
   c) Estimate the conductivity of a 60% Si - 40% SiO_2 composite at 200°C.




Conductivity of Si particles in
SiO2 matrix at Room Temperature
Conductivity (Ωm)-1
10-4
10-6
10-8
10-10
10-12
10-14
0
0.2
0.4
0.6
0.8
1
Volume Fraction Si