Engineering Materials, Course No. 4202402, CCU ME

Mid-term Exam (I) **101. 11. 06.** **Lectured by:敖仲寧**

1. Total score: 120, **2.** Close-book, **3.** Using calculator is allowed, **4.** Keep question sheets and return answering sheets.

1. (a) List the three basic classifications of solid materials. What is called a material made of the combinations of the basic materials? **(4%)**

(b) List three advanced materials. **(3%)**

(c) What is a memory alloy? Give an example of its application. **(4%)**

2. Figure 2 shows three different crystallographic planes for a unit cell of a hypothetical metal. The Miller indices of these crystallographic planes and a crystallographic direction on each plane are shown. The circles represent atoms.

(a) Draw the 3-D view of the unit cell with atoms at atomic sites and indicate the three planes and three directions in fig.2 on the 3-D unit cell. **(8%)**

(b) To what crystal system does the unit cell belong? What do we call this crystal structure? **(5%)**

(c) Determine the planar density of the (1 1 0) plane. **(5 %)**

(d) If the atomic weight of the metal is 113.2 g/mol, determine the theoretical density of this metal. **(6%)**

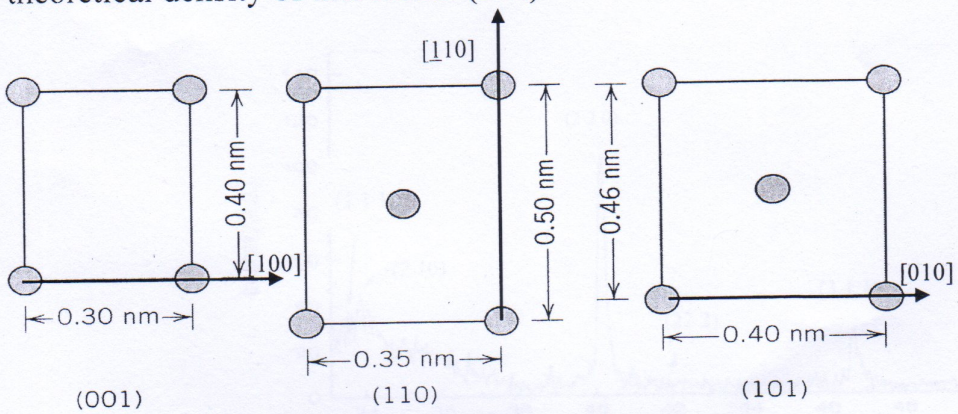

Figure 2

3. (a) Give the coordination number CN of a BCC, an FCC and an HCP structure respectively. **(3 %)**

(b) Why do the FCC and HCP structures have the same CN and the same atomic packing factor? Explain in detail. **(9%)**

(c) Show that the minimum cation-to-anion radius ratio r/R for the CN=4 is 0.225. **(8 %)**

4. (a) A crystallographic plane of a cubic structure intercepts x-, y- and z-axis within a unit cell at *a, 1/2 a*, and *1/3 a* respectively. Determine the Miller indices of this plane. **(5 %)**
(b) Determine the Miller indices of the intersection line between plane in (a) and (101) plane. **(5 %)**
(c) List an arbitrary crystallographic direction which lies on the (1 1 $\bar{2}$) plane. You must prove it. **(5 %)**

5. The following diffractometer data (expressed as 2θ) were generated from a specimen: An X-ray diffraction experiment on a pure metal generated diffraction peaks at 14.2°, 20.0°, 24.6°, 28.4° and 31.8°. The X-ray was irradiated with a silver target having a wavelength of 0.574 Å.
(a) Index the planes (h k l) representing these five peaks. **(10%)**
(b) Determine the crystal structure. **(5 %)**
(c) Determine the interplanar spacing of the first **two** peaks **(6%)**
(d) For the first peak, determine the atomic radius of this metal. **(5%)**
(e) Identify the pure metal from the attached table **(3%)**
(f)Figure 5 shows another X-ray diffraction result having five peaks. Which three of these five peaks were wrongly indexed? Correct them with correct indices. **(6%)**

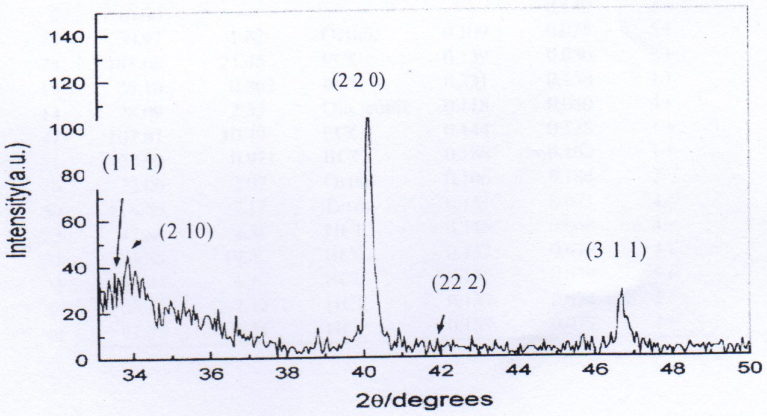

Figure 5

6. Determine Miller-Bravais indices ***step by step!***
(a) Crystallographic plane **(5%)**
(b) Crystallographic plane **(5%)**
(c) Crystallographic direction PE. **(5%)**

Characteristics of Selected Elements

Element	*Symbol*	*Atomic Number*	*Atomic Weight (amu)*	*Density of Solid, 20°C (g/cm³)*	*Crystal Structure, 20°C*	*Atomic Radius (nm)*	*Ionic Radius (nm)*	*Most Common Valence*	*Melting Point (°C)*
Aluminum	Al	13	26.98	2.71	FCC	0.143	0.053	3+	660.4
Argon	Ar	18	39.95	—	—	—	—	Inert	−189.2
Barium	Ba	56	137.33	3.5	BCC	0.217	0.136	2+	725
Beryllium	Be	4	9.012	1.85	HCP	0.114	0.035	2+	1278
Boron	B	5	10.81	2.34	Rhomb.		0.023	3+	2300
Bromine	Br	35	79.90	—	—	—	0.196	1−	−7.2
Cadmium	Cd	48	112.41	8.65	HCP	0.149	0.095	2+	321
Calcium	Ca	20	40.08	1.55	FCC	0.197	0.100	2+	839
Carbon	C	6	12.011	2.25	Hex.	0.071	~0.016	4+	(sublimes at 3367)
Cesium	Cs	55	132.91	1.87	BCC	0.265	0.170	1+	28.4
Chlorine	Cl	17	35.45	—	—	—	0.181	1−	−101
Chromium	Cr	24	52.00	7.19	BCC	0.125	0.063	3+	1875
Cobalt	Co	27	58.93	8.9	HCP	0.125	0.072	2+	1495
Copper	Cu	29	63.55	8.94	FCC	0.128	0.096	1+	1085
Fluorine	F	9	19.00	—	—	—	0.133	1−	−220
Gallium	Ga	31	69.72	5.90	Ortho.	0.122	0.062	3+	29.8
Germanium	Ge	32	72.59	5.32	Dia. cubic	0.122	0.053	4+	937
Gold	Au	79	196.97	19.32	FCC	0.144	0.137	1+	1064
Helium	He	2	4.003	—	—	—	—	Inert	−272 (at 26 atm)
Hydrogen	H	1	1.008	—	—	—	0.154	1+	−259
Iodine	I	53	126.91	4.93	Ortho.	0.136	0.220	1−	114
Iron	Fe	26	55.85	7.87	BCC	0.124	0.077	2+	1538
Lead	Pb	82	207.2	11.35	FCC	0.175	0.120	2+	327
Lithium	Li	3	6.94	0.534	BCC	0.152	0.068	1+	181
Magnesium	Mg	12	24.31	1.74	HCP	0.160	0.072	2+	649
Manganese	Mn	25	54.94	7.44	Cubic	0.112	0.067	2+	1244
Mercury	Hg	80	200.59	—	—	—	0.110	2+	−38.8
Molybdenum	Mo	42	95.94	10.22	BCC	0.136	0.070	4+	2617
Neon	Ne	10	20.18	—	—	—	—	Inert	−248.7
Nickel	Ni	28	58.69	8.90	FCC	0.125	0.069	2+	1455
Niobium	Nb	41	92.91	8.57	BCC	0.143	0.069	5+	2468
Nitrogen	N	7	14.007	—	—	—	0.01–0.02	5+	−209.9
Oxygen	O	8	16.00	—	—	—	0.140	2−	−218.4
Phosphorus	P	15	30.97	1.82	Ortho.	0.109	0.035	5+	44.1
Platinum	Pt	78	195.08	21.45	FCC	0.139	0.080	2+	1772
Potassium	K	19	39.10	0.862	BCC	0.231	0.138	1+	63
Silicon	Si	14	28.09	2.33	Dia. cubic	0.118	0.040	4+	1410
Silver	Ag	47	107.87	10.49	FCC	0.144	0.126	1+	962
Sodium	Na	11	22.99	0.971	BCC	0.186	0.102	1+	98
Sulfur	S	16	32.06	2.07	Ortho.	0.106	0.184	2−	113
Tin	Sn	50	118.69	7.17	Tetra.	0.151	0.071	4+	232
Titanium	Ti	22	47.88	4.51	HCP	0.145	0.068	4+	1668
Tungsten	W	74	183.85	19.3	BCC	0.137	0.070	4+	3410
Vanadium	V	23	50.94	6.1	BCC	0.132	0.059	5+	1890
Zinc	Zn	30	65.39	7.13	HCP	0.133	0.074	2+	420
Zirconium	Zr	40	91.22	6.51	HCP	0.159	0.079	4+	1852