Name: _____

Advanced Solid State Physics — Prof. Dr. W. Kuch
Winter semester 2014/2015
6th exercise sheet

Submission: Tuesday, 25. November 2014, before the lecture
(or drop until 10 o'clock on the same day in mailbox between rooms 1.2.38 and 1.2.40)

**16. Recapitulation of introductory solid state physics: Fermi surfaces** (**) (4 points)
Cu has an *fcc* lattice with lattice constant $a$ = 3.61 Å and a Fermi energy of 8.5 eV. Sketch two-dimensional cuts through the three-dimensional Brillouin zone to yield (100) and (110) planes including the Γ point, and label the main symmetry points. (Attention! These cuts are not identical to the projected two-dimensional Brillouin zones!) Indicate in the sketches the Fermi surface of free electrons with a Fermi energy of 8.5 eV. Extend the sketch of the (110) plane periodically around one X point by one reciprocal lattice vector.
Hint: Look at the sketch of the three-dimensional Brillouin zone of *fcc* crystals in textbooks, or on page 48 of the lecture notes.

**17. Surface alloy** (**) (4 points)
If Mn atoms are deposited on a (001) surface of Cu, a MnCu surface alloy forms in which an equal number of Mn and Cu atoms are arranged in a checkerboard-like c(2x2) pattern (see sketch at exercise 5 of the 2nd exercise sheet), where Mn atoms substitute Cu atoms, such that the distance between nearest neighbor atoms is the same as in Cu.

a) Sketch the two-dimensional surface Brillouin zone for this two-dimensional surface layer and determine its size in $k$ space. Cu has an *fcc* lattice with a (volume) lattice constant $a$ = 3.61 Å. Make sure to consider the different periodicity of this surface alloy compared to the pure Cu surface.
b) Calculate the energies of all two-dimensional bands of free electrons in this surface alloy at the $\bar{\Gamma}$ point in the range of 0–100 eV.

**18. Surface state of Cu(111)** (**) (4 points)
The energy dispersion of the Shockley surface state of Cu(111) can be approximated by the parabola $E = \frac{\hbar^2 k_{\parallel}^2}{2m^*} - E_0$, where $m^* = 0.45\ m_e$, $E_0 = 0.4$ eV, and the energy E is given relative to the Fermi energy. How many electrons per surface atom occupy this surface state under this approximation? (Cu: *fcc*, $a$ = 3.61 Å.)