Preparation and characterization of spin polarized tips for tunneling microscopy

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Nowadays we are getting closer to the limits of current technologies, for example in electronics we need to study electric and magnetic properties at the atomic level to really push the technology forward. Spin polarized Scanning tunneling microscopy (SP STM) and derived methods are unbeatable in this aspect, it can study electric and magnetic properties of single atoms or molecules. It uses an atomically sharp tip to scan the sample. Electrons tunneling between tip and sample create an electric current that we can measure. This current is very sensitive to the distance between the tip and the atoms at the sample surface. So, we can get topological representation of the sample with atomic resolution. The aim of this work was to verify and improve new method of SP STM tip preparation from $Mn_{88}Ni_{12}$ published by Forester et. al. Because SP STM tips from standard spin polarized materials, like Cr or Fe are due to their mechanical and chemical properties hard to prepare and not well reliable.
In experimental part, I first reproduce the $Mn_{88}Ni_{12}$ tip electrochemical etching preparation method using an electrolyte meniscus supported by Pt ring. This etches a $Mn_{88}Ni_{12}$ wire into two possible tips giving higher yields than standard procedures. Then, by optimizing etching parameters and extensively experimenting with different possible electrolytes as sulphuric, formic, acetic, and other acids, I have improved the tip preparation method. I found that the best results were obtained using 10% hydrochloric acid. Tip quality analysation was conducted by optical microscopy with the use of scanning electron microscopy for electrolyte effects inspection. The best tips were used chosen for subsequent SP STM experiments.
The last step was to verify the spin polarization (SP) of $Mn_{88}Ni_{12}$ tips. In this experiment with Co islands on Cu(111), the Co atoms create islands of two orientations. The same orientation has always the same local density of states, which can be measured by the 1^{st} derivative of the tunneling current by the tunneling voltage (dI/dV). However, the same orientation can sometimes have different SP, which then affects the dI/dV; this signal difference on islands of the same orientation can only be captured by a spin polarized tip. I have measured this difference confirming the SP of $Mn_{88}Ni_{12}$ tips. I doubled the success rate of etching these tips from 20 % to 40 % and shortened the preparation time down to 15 - 20 seconds from 4 - 5 minutes. This method allows now faster on-site preparation of spin polarized STM tips and is cheaper. The cost per tip is under 10 € compared to commercial tips sold above 100 €.