**RESPONSE TO REVIEWERS**

28.12.2018., Belgrade

Dear Reviewer,

I would like to thank you for the corrective suggestions of our work. Below are the answers to your comments.

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| **Comments** | **Answers** |
| Title: the influence of the mixing conditions is underlined in the title, and in the whole manuscript the influence of the substrate type is much more pronounced. Please comment and explain. Besides, different mixing conditions were mentioned in the Title, and in one case silent bath, with no agitation/mixing, was used and in another US agitation/mixing was utilized.  | The title of work has been changed in terms of emphasizing the mechanical characterization of copper films electrodeposited on different substrates. |
| Abstract: The first sentences should be corrected since it seems that two different coatings were examined, instead of two substrates.  | Sentence is corrected. |
| Abstract: “Copper films electrodeposited with the assistance of ultrasound are fine-grained and bright on both substrates….” Where was the brightness analyzed and discussed in the manuscript? | The abstract was corrected, brightness was not examined in the work and it was deleted. |
| It is not clear why Authors choose these two substrates. What property did they want to compare?  | The intention was to choose two substrates different in their roughness to analyze and test the hardness and adhesion models for the copper films on them. |
| Page 2, line 53: “A thin film on a substrate can be considered as a composite system which properties depend...... ” Not every thin film is a composite. In this case, pure Cu coating could not be considered a composite coating.  | Sentence has been changed to: „ A coating and a substrate can be considered together as a composite system which properties depend not only...“ |
| Why particular plating parameters were used (50 mAcm-2, temperature 25 °C and pH- 0.30)? If they were chosen based on some earlier research than the reference to this work should be provided. It is important to indicate what property was aimed for achieving with this bath.  | References relating to the selection of experimental parameters are added to the text and list of references. |
| The thicknesses of 20 and 50 μm should be referred to as coating rather than film.  | „Film“ is replaced with „coating“ in the entire text. |
| Was the Cu deposit thickness measured and checked on both substrates? This is especially important since it was stated in the Introduction that: “The measured hardness is influenced by a number of factors such as film thickness,….” | Deposition rate was determined for electrodeposition with and without ultrasound agitation. The projected thickness of 20 µm was the parameter that was controlled. |
| Does the US agitation influence the coating thickness (given the same other plating parameters)?  | Yes, it does, the deposition rate is higher. But, this is not relevant to the research problem, because the selected film thickness was constant. |
| Fig. 3 i 4: is x-axis logarithmic: If it is, than appropriate ticks should be given.  | Figures 3 and 4 are corrected and appropriate ticks are given. |
| Page 7, lines 173-174: “As shown in Table I, the ultrasonic agitation contributes to the increase of the electrodeposited copper films hardness.” It seems that the type of the substrate has more influence on the hardness values than the US agitation. Please comment. | The comment is given. The choice of the substrate has been shown to have a greater influence on the type of the electrolyte mixing. |
| Table I: what are parameters k and RMSE? They should be defined and discussed, not simply listed.  | The parameter k’ from Korsunsky model is defined. |
| Page 9, lines 192-193: “Surface roughness of the films were determined by their root-mean-square (Rq) and average roughness (Ra)….” These parameters should be defined so that the difference among them could beclear. Besides, these parameters should be discussed, not simply listed.  | Parameters Ra and Rq are defined and discussed in the text.  |
| The influence of the substrate type on the surface roughness is more pronounced than the US agitation. It would be nice to know the roughness of the substrates, since they seem to influence roughness of the Cu coating. Moreover, the brass substrate pretreatment is also important, since different types of the pretreatment (such as different time of chemical polishing) would probably result in different substrates roughness values, and finally in different Cu coating roughness’s. So, it is not clear why two substrates of such different roughness's were chosen as substrates. The role of Ni coating should be explained, especially since Ni was deposited from the bath providing a fine morphology, and as Authors state on page 9, line 199: “fine-grained 50 μm-thick ED Ni film as the substrate” was used. If the idea was to suppress the influence of brass substrate by Ni deposition, than it should be clearly pointed why Ni was chosen, since it could easily be taken that many coating types deposited as fine grained ones would result in the small surface roughness and consequently in increased hardness.  | Nickel and copper are materials that are compatible with MEMS technologies and therefore the research is related to them of exceptional importance. They allow the fabrication of multilayered structures that are used as such, or 3D microstructures can be formed by selective etching. Hardness and adhesion of coatings and substrates are of great importance because of the integrity of microdevices.It was the idea to suppress the influence of brass substrate by electrodeposition of 50 µm Ni coating (ref. 20) and it is now explained in the text. |
| Page 11, lines 230-231: “According to Fig.6, it can be concluded that quality of adhesion can be assessed based on microhardness measurements.” Isn’t this well known? | Yes, this is. Yes. We concluded from the literature that the possibility of quantitatively expressing adhesion strength through the measured values ​​of microhardness in the field of research of mechanical properties of coatings on substrates remains a topical issue. |
| Authors should discuss why both Ni substrate and US were beneficial for Cu coating hardness and adhesiveness. | Nickel and copper are materials of significance for MEMS, especially their mechanical properties. Introduction of ultrasound into electrodeposition process represents a possible way to obtain multilayer coatings for MEMS structures, by alternating deposition of Ni and Cu or by alternating deposition of ordinary Cu and US Cu coatings. |

Best regards,

Jelena Lamovec