doi:10.1017/S1431927621002944
Microsc. Microanal. 27 (Suppl 1), 2021


# Tuning the electrodeposition texture of β-Sn coatings for enhanced corrosion resistance

Abhay Gupta[1] and Chandan Srivastava[2]

[1]IISc Bangalore, Karnataka, India, [2]IISc Bangalore, Bengaluru, Karnataka, India

Sn electrodeposits are extensively used in the electronics industry as interconnects [1]. It is so often observed that the failure of electronic components happens at the interconnect due to whiskering, thermomechanical stresses, and corrosion. This work focuses on improving the corrosion resistance of the Sn electrodeposits by modifying their crystallographic texture and the grain boundary constitution by tuning the electrodeposition temperature.

Tin electrodeposition was performed over polished mild steel substrates by the galvanostatic method using the two-electrode DC power supply. The aqueous electrolyte for electrodeposition contained tin sulphate, methane sulphonic acid, hydroquinone, and gelatin. Four different temperatures were chosen for the electrodeposition: 24 ˚C, 47 ˚C, 70 ˚C, and 80 ˚C. The Sn coatings were subjected to corrosion analysis using the Tafel polarization measurements (Figure 1(a)), and the corrosion resistance data was correlated with the electron backscattered diffraction (EBSD) results. From the Tafel polarization results it was observed that the Sn coating fabricated at 70 ˚C exhibited the highest corrosion resistance (corrosion current density, icorr = 2.77 × 10−8 A/cm2) while the corrosion resistance of Sn coating fabricated at 80 ˚C was the least (icorr = 4.25 × 10−7 A/cm2). The icorr values for Sn deposited at 24 ˚C and 47 ˚C were 1.43 × 10−7 A/cm2 and 1.16 × 10−7 A/cm2, respectively.

The inverse pole figure (IPF) maps and the IPFs (Figure 1(a-d)) show that the Sn coatings fabricated at 24 ˚C and 47 ˚C have a 'near-(110)' orientation texture of the surface exposed to the corrosive medium. In comparison, the one fabricated at 70 ˚C exhibits low surface energy (001) and (100) texture [2-3]. Sn coating electrodeposited at 80 ˚C exhibited a primary orientation at (001) along with a minor orientation maximum at (331), which is a near-(110) orientation. From the IPF maps, an increase in grain size with an increase in electrodeposition temperature can also be observed (Figure 1(g)). The misorientation angle distribution plot in Figure 2(a) shows a minor peak at near-60˚ misorientation angle, which may indicate the presence of Σ33a (031)[01-3] twin boundary at 62.8˚ misorientation. The misorientation axis distribution plots in Figure 2(b) show that all the Sn coatings exhibit MRD maximum at (100) axis. The grain boundary plane distribution (GBPD) along the 62.8˚/[100] misorientation angle-axis pair shows high intensity at (031) pole for Sn coatings prepared at 47 ˚C, 70 ˚C, and 80 ˚C, which indicates a high population of Σ33a (031)[01-3] twin boundary. The Σ33a boundary is a low energy boundary in β-Sn structure. The presence of a high fraction of Σ33a twins and a high fraction of low angle grain boundaries strengthen the grain boundary constitution of Sn coatings. Furthermore, the low surface energy atomic planes exposed to corrosive medium also slow down the corrosion of a metal. The high corrosion resistance of the Sn coating deposited at 70 ˚C can be attributed to the following factors: (i) crystallographic texture along low energy (001) and (100) orientations, (ii) high fraction of low angle grain boundaries(LAGBs) (Figure 2(d)), and (iii) high fraction of Σ33a twins. Low fraction Σ33a twin boundaries coupled with near-(110) orientation texture exposed towards corrosive medium led to the low corrosion resistance of the Sn coating deposited at 80 ˚C.

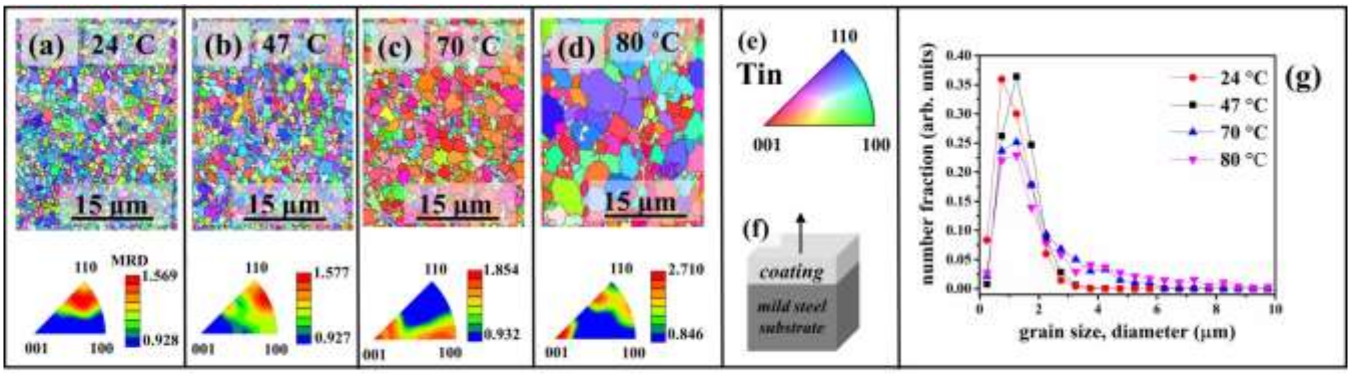
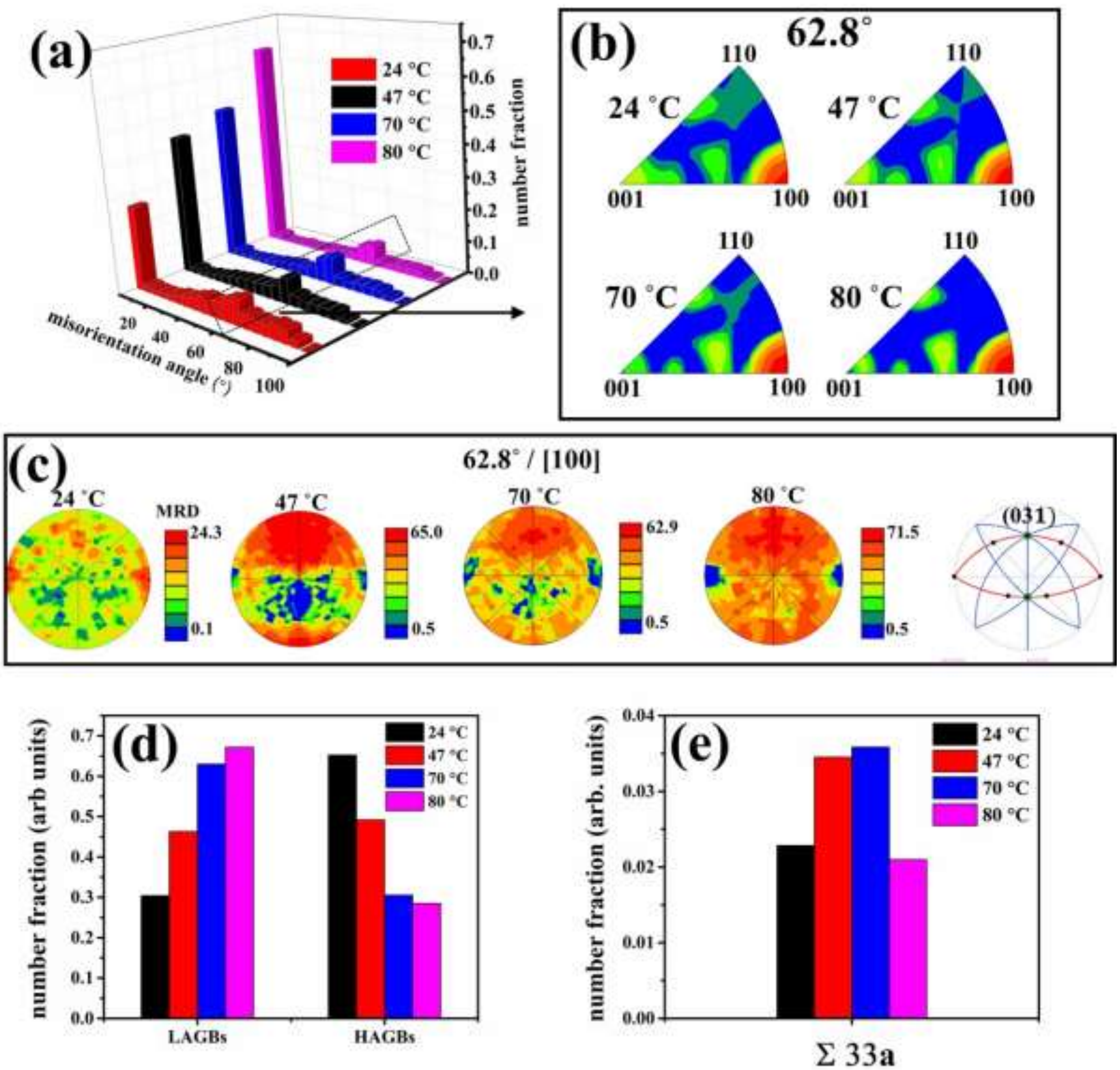



**Figure 1.** Figure 1. Inverse pole figure (IPF) maps and the IPF for the Sn coatings deposited at (a) 24 ˚C, (b) 47 ˚C, (c) 70 ˚C, and (d) 80 ˚C. (e) legend representing color based orientation in IPF maps. (f) the direction of view of IPF maps. (g) grain size distribution in the Sn coatings.




https://doi.org/10.1017/S1431927621002944 Published online by Cambridge University Press

**Figure 2.** Figure 2. (a) Misorientation angle distribution in Sn coatings(Sn coating deposited at: 24 ˚C – red, 47 ˚C – black, 70 ˚C – blue, and 80 ˚C – pink). (b) Misorientation axis distribution at 62.8˚ misorientation. (c) Grain boundary plane distribution (GBPD) along the 62.8˚/[100] misorientation for all the Sn coatings. (d) The relative fraction of low and high angle grain boundaries. (e) Fraction of (031)[01-3] symmetric twin boundaries in all Sn coatings.

References

[1] Z.L. Ma , S.A. Belyakov , K. Sweatman , T. Nishimura , C.M. Gourlay , Nat. Commun. 8 (2017) 1916.
[2] M.S. Sellers , A.J. Schultz , C. Basaran , D.A. Kofke , Appl. Surf. Sci. 256 (2010) 4402–4407.
[3] P. Jagtap , P. Kumar , J. Electron. Mater. 44 (2015) 1206–1219.

https://doi.org/10.1017/S1431927621002944 Published online by Cambridge University Press