CHAPTER-VI

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The summary of the work on soft gold deposition on nickel coated copper substrate is presented below,

1. The disadvantages of cyanide complex baths have driven to the use of gold-sulfite or gold-thiosulphate acidic baths. Improved stability for such baths has demanded the use of gold thiosulphate-sulfite complex baths.

2. To improve the quality of the deposits and to achieve better throwing power, plating rate and current efficiency different stabilizing agents and additives have been tried.

3. Of the two stabilizing agents EDTA and citric acid, the latter one is found to give better performance than EDTA.

4. The gold plating bath can operate at pH 6 and was stable for periods of one month for thiosulphate-sulfite bath beyond which the colour of the bath solution changed into yellow colour. However with the use of the stabilizing agents no colour change in the bath was perceived even after two months of ageing. With citric acid the period was more than 75 days.

5. The wavelength of absorbance for gold is shifted towards less energy side by the addition of EDTA (290nm) and citric acid (304nm) than that occurred with simple gold-thiosulphate (285nm) and gold-sulfite

(273nm) baths indicating the energetic of the complexes. Further, the absorbance for gold occurs at 283nm in the thiosulphate-sulfite bath.

6. Of the different additives used, thiourea is recommended as a useful additive for thiosulphate-sulfite bath and thiosulphate-sulfite (EDTA) stabilized baths. Pyridine and SLS are recommended for thiosulphate-sulfite (citric acid) stabilized bath.

7. Cyclic voltammetric studies are helpful in understanding the mechanism of the deposition process. The calculated α_n, D and Ks values indicate the basic deposition mechanism is not altered due to the presence of either the stabilizing agents or the additives. The presence of sulfite ligand is only to shift the disproportionation equilibrium of thiosulphate infavour of the latter and the reduction mechanism is one of involving the species $(Au_2S_2O_3)_{ads}$ in the rds.

8. The X-ray diffraction studies in the asplated and heat treated conditions indicate the crystallographic structure of the deposits to be Au fcc with a slight (111) preferred orientation with lattice parameters a=b=c=5.096A and $\alpha=\beta=\gamma=90°$.

9. The SEM and EDAX studies indicate the fine-grained structures with 96 at. Wt % Au purity. The sulphur inclusion in the deposits from the adsorbed intermediate $Au_2S_2O_3$ could not be ruled out.

10. The nearly pore-free (less than 2-4 pore/cm^2), good adherent deposits with moderate hardness values (80-130 VHN) indicate that the deposits are useful as soft gold for microelectronic application and thermocompression bonding purposes.

11. The R_t values indicate that with the presence of the citric acid stabilizing agent, the charge transfer cathodic rate is faster than in presence of EDTA. The pyridine and thiourea will be good addition agents in enhancing the deposition rates further. Aniline and SLS may not be useful for speedy depositions.

12. After optimizing the bath parameters with acidic gold thiosulphate-sulfite bath, EDTA and citric acid were tried as the stabilizing agents. The optimized plating parameters are mentioned below.

Parameters	**Systems**		
	Thiosulphate-sulfite	**Thiosulphate-sulfite (EDTA)-bath I**	**Thiosulphate-sulfite (Citric acid)-bath II**
pH	6	6	6
Temperature (°C)	60	60	60
Bath load (M)	0.5	0.2	0.3
Current density A/dm^2	2	2	2
Rate of deposition, μm/hr	6.2	8.4	9.3
Current efficiency, %	92	98	97
Throwing power, %	64	76	82

13. The improvements in important plating parameters with baths I & II in presence of the additives are as follows.

Systems	Name of the additive	Rate of deposition (μm/hr)	Current efficiency, %	Throwing power, %
Bath I	Aniline	12	92	86
	Pyridine	11	92	89
	SLS	13	90	78
	Thiourea	14	98	90
Bath II	Aniline	13	88	81
	Pyridine	12	96	83
	SLS	13	92	79
	Thiourea	11	98	84

14. For the recovery of gold from electroplating waste solutions or discharge, eggshell membrane has been tried as potential adsorbent for gold recovery with maximum efficiency.

As the over all conclusion from the studies the following bath is recommended as the best performing non-cyanide acid bath for soft gold deposition purposes

Constituents & plating conditions

$HAuCl_4$	0.15M
Sodium sulfite	0.5M
Sodium thiosulphate	0.5M
Citric acid	0.3M
pH	6
Temperature	60°C
Current density	2 A/dm^2