LITERATURE SURVEY AND
SCOPE OF THE PRESENT WORK
CHAPTER-II

LITERATURE SURVEY & SCOPE OF THE PRESENT WORK

2.1 Introduction

Nanocomposite coatings are prepared by electrodeposition method. These coatings are obtained by suspending submicron size particles in the electrodeposition bath. These composite deposits have improved wear resistance, microhardness and strength compared to those of their corresponding metals or alloy deposits. It is well known that nickel electrocomposite coatings can be easily obtained from a nickel bath and number of studies on electrocomposites by using a nickel bath have been reported from a technological point of view [1-10].

In the past decades, the interest in copper matrix composite coatings has increased owing to their potential engineering applications resulting from the outstanding properties of wear-resistance, anticorrosion and self-lubrication of such materials. The codeposition of alumina, silicon carbide, boron carbide etc with copper from a copper cyanide plating bath or an acid sulphate bath can be obtained [11-12]. Copper-based electrocomposites containing those solid particles were developed for their improved wear resistance. Soft and self-lubricating particles like polytetra-fluoroethylene (PTFE), molybdenum sulfide, graphite and talc are codeposited with copper to create nonstick, low-friction coatings [13-20]. Numerous studies have been devoted to electrodeposited copper-based composites, but very few have dealt with the influence of particle type on the codeposition process and properties of the resulting electrocomposites.

Celsis et al reported the kinetics and mechanism of copper-Al2O3 nanocomposite coatings [21, 22]. Lozano-Morales et al have studied the
incorporation of Al2O3 nanoparticles on copper electrodeposits [23]. Yang et al reported the preparation of single-walled carbon nanotube-reinforced copper composite coatings by electroplating [24]. Dongming Guo et al reported the pulse plating of Copper-ZrB2 composite coatings [25]. Benea et al reported the corrosion behaviour of copper and copper-matrix composite coatings with ZrO2 particles embedded obtained from an acid copper sulphate plating bath [26, 27]. Stankovic et al reported the electrodeposited composite coatings of copper with inert, semiconductive and conductive particles which included the particles α-Al2O3, SiC, MoS2, and graphite [28]. Bund et al reported the effect of pH and electrolyte composition on the electrodeposition of copper-matrix and nickel-matrix alumina composites [29]. Medeliene et al reported the copper metal matrix composite electrodeposited from aqueous suspensions with nanosize particles of anatase and rutile [30].

2.2 CeO2 based metal nanocomposites

Cerium oxide is a very promising material, which has many potential applications. CeO2 as a pure compound is a good candidate for the new generation oxygen sensors [31]. Cerium oxide has been widely used as a catalytic promoter for the elimination of toxic exhaust gases in automobiles [32, 33]. Cerium oxide based solid solutions have already been considered as possible substitutes for zirconia for fuel cell applications due to their higher ionic conductivity in comparison to zirconia ceramics [34, 35]. Ceria thin films can be used as high refractive index materials and insulating films on semiconductors. Ceria composites have useful applications as they have better mechanical, catalytic, electronic and corrosion protection properties [36-40].
Rare earth oxides have been widely used in electronics, materials and chemical engineering due to their special characteristics [41, 42].

Yu-Jun Xue et al reported that the tribological performance of Ni-CeO₂ composite coatings obtained by electrodeposition technique. It was found that Ni-CeO₂ composite coating possessed better wear resistance than pure nickel coating and this wear behaviour was closely related with the CeO₂ content in the coating [43].

Electrodeposited Ni/ceria nanocomposites coating was found to have enhanced corrosion resistance and microhardness than the electroplated nickel [44]. Carac et al also demonstrated the codeposition of micron CeO₂ particles with nickel-cobalt [45].

Qu et al reported the fabrication of Ni-CeO₂ nanocomposites by electrodeposition which exhibited finer nickel grains, higher microhardness, better wear resistance, improved corrosion resistance and enhanced high temperature oxidation resistances [46].

Baolei Han et al reported the tribological and anti-corrosion properties of Ni-W-CeO₂ coatings which showed high temperature tribological properties and also superior corrosion resistance than Ni-W coating [47].

Dongyun Lee et al reported the influence of ultrasonic irradiation on the microstructure of Cu/Al₂O₃, CeO₂ nanocomposite thin films during electrocodeposition. The effects of Ultrasonic irradiation on agglomeration during electrocodeposition of Cu-Al₂O₃ and Cu-CeO₂ nanocomposite thin films on a silicon substrate were investigated. In addition, the effect of electrolyte concentration on agglomeration of nanoparticles was also investigated. Irradiation by ultrasound during electrocodeposition yielded smaller grain size, improved surface conditions,
decreased agglomeration and higher volume fraction of nanosized inert particles within the nanocomposite thin films [48]. Joe Edington et al reported the development of a spontaneous immersion process for the deposition of cerium oxide coatings on copper substrates [49].

2.3. TiO₂ based metal nanocomposites

Titania film composites also have useful mechanical and corrosion resistant properties. Li et al reported that, electrodeposited titania-nickel nanocomposite coatings consisting of a nanocrystalline nickel matrix (average grain size of 10 nm) and nanometer-sized titania particles dispersed in a nickel matrix had good mechanical and corrosion resistance performance. Vickers microhardness and corrosion resistance of the nanocomposite coatings increased with increasing content or decreasing grain size of titania particles in the composite coatings [50, 51].

Praveen et al have reported the electrodeposition and properties of Zn-nanosized TiO₂ composite coatings [52, 53]. The Zn–TiO₂ composite films prepared by pulsed electrodeposition were reported by Gomes et al [54]. Praveen et al [53] have reported the corrosion Behavior of Zn–TiO₂ Composite Coating. The TiO₂ nanoparticles were dispersed uniformly in the solution and included in the zinc coating during electrodeposition. The incorporation of TiO₂ in the coating led to improvement in the crystal size and enhanced corrosion resistance, microhardness and wear resistance property than the conventional zinc coatings. The TiO₂ particles occupied the crevices, gaps and micron holes on the surface of the zinc coating enhancing their uniform distribution in the zinc coating. They caused the displacement of the open circuit potential of the composite coating towards more positive values. The composite coating exhibited uniform corrosion. This excellent corrosion resistance,
wear resistance and microhardness of the composite coatings found their applications in wide range of modern industries.

Denny Thiemig et al reported the characterization of electrodeposited Ni–TiO$_2$ nanocomposite coatings [55]. Spanou et al reported the Ni/nano-TiO$_2$ composite electrodeposits for their textural and structural modifications [56]. Sun et al reported the friction and wear properties of electrodeposited Nickel–Titania nanocomposite coatings. Titania nanoparticles in the nanocomposite coatings could be controlled by changing the concentration of the suspending titania nanoparticles in the plating bath. As the particle concentration increased from 0 to 100 g/l, the content of the TiO$_2$ particles in the nanocomposite coatings increased reaching the maximum incorporation percentage of 9 vol % at low current densities and low pH values. The concentration of the codeposited particles affected the grain size of metal crystallites and enhanced the quality of the preferred crystal orientation. TiO$_2$ nano-particles in the composite coatings were dispersed uniformly in the nickel matrix on the surface as well as, through the cross-section of the deposits and the incorporation of the nano-particles took place between the grains. The surface morphology, Vickers microhardness, friction coefficient, and wear rate closely depended on the content of the titania nanoparticles. Compared with the nanocrystalline nickel coatings electrodeposited under the same conditions, titania–nickel nanocomposite coatings exhibited smoother surfaces, higher hardness, and lower friction and higher wear resistances [57].

Fawzy et al electrodeposited Cu-α-Al$_2$O$_3$ and Cu-TiO$_2$ composites from acidic baths. They observed that there was a parallelism between the increase in microhardness and the increase in the α-Al$_2$O$_3$ and TiO$_2$ wt % codeposited with copper [58].
Medelieene et al reported the preparation of Cu-TiO₂ composites by the aqueous suspension of the nanometric size particles of anatase and rutile TiO₂ in copper bath [59].

2.4 ZrO₂ based metal nanocomposites

Zirconia (ZrO₂) is interesting as a ceramic material with useful optical, electrical, thermal, hardness and other characteristics. Typical properties exhibited by zirconia are high strength, high fracture toughness, excellent wear resistance, high hardness, excellent chemical resistance, high toughness, very refractory, good oxygen ion conductor etc. Typical applications include are knives and scissors, seals, valves and pump impellers, orthopaedic implants, refractory and other electronic applications etc.

Fengyan hou et al reported the effect of the dispersibility of ZrO₂ nanoparticles in Ni-ZrO₂ electroplated nanocomposite coatings on the mechanical properties of nanocomposite coatings [60]. The hardness of all the Ni-ZrO₂ nanocomposite coatings were two-three times higher than that of pure nickel coatings. Wei wang et al reported the fabrication and characterization of Ni-ZrO₂ composite nanocoatings by pulse electrodeposition [61].

Benea et al reported the corrosion study of copper composite coating by impedance spectroscopy method [62-64]. Cu-ZrO₂ composite showed three times higher corrosion resistance than the copper deposit in sulphuric acid medium. They also reported that the electrodeposition of zirconia particles in a copper matrix [65].
2.5 PANI based metal nanocomposites

Polyaniline is one of the most studied electrically conducting polymers. It exists in a variety of forms that differ in the degree of oxidation and/or protonation, and consequently in physico-chemical properties [66-68]. It is easily prepared by the chemical or electrochemical oxidation of aniline. Polyaniline dispersions can then be used in electrodeposition experiments [69, 70]. The use of polyaniline in the anti-corrosion treatment of metal surfaces is known [71, 72].

Nickel-PTFE coatings have been widely used in industries. They provided non-stick, non-fouling, lubricating, and low friction coating. They were good wear and corrosion resistant [73–88].

Yoshihiro Haseko et al reported reversal pulsing electrodeposition of Ni-Polypyrrole composite film was more corrosion resistant than electroplated Nickel [89].

Abdel Hamid et al reported the characteristics of electrodeposition of Ni-Polyethylene composite coatings, and the possibility of incorporation of fine polyethylene (PE) particles in a nickel matrix was also studied systematically with a Watts bath. The hardness, wear and corrosion resistance of the composite were found to be greater than free nickel deposits [90].

2.6 MWCNT based metal nanocomposites

Carbon nanotubes (CNTs) have attracted tremendous interest after been discovered by Iijima from the fundamental and applied perspective. Carbon nanotubes (CNTs) are one of the most important one dimensional materials. Thus, carbon tubes have been applied as remarkable functional materials, such as carriers of catalyst, microelectrodes, hydrogen storage materials and super capacitors etc.
The novel electronic properties of the carbon nanotubes led to the application in nano devices, such as nanodiodes, nano transistors and other important applications [95, 96]. The carbon nanotubes were found to be superstrong. Wong et al used the atomic force microscope to determine the mechanical properties of the multiple-wall nanotubes (MWSTs) [97]. The novel mechanical properties found applications in the needle-like tips of atomic imaging machines. CNTs content in metal–CNTs composite coatings can improved the wear resistance, hardness and corrosion resistance of the coatings [98-100]. The CNT-reinforced metal composites prepared by electrodeposition had high hardness, excellent wear resistance and good resistance to corrosion [101-104]. However, the effective fabrication of CNT-reinforced metal depended on the homogenous dispersion of CNTs in the metal matrix and the interfacial adhesion between them. Due to its excellent electrical conductivity, pure copper was widely used in the electronics industry, but its intrinsic softness often caused the failure of electronic components. Strengthening metals, such as pure copper, through various approaches usually led to a pronounced decrease in conductivity [105]. It was found that SWCNT-reinforced metals have prominent enhancement in mechanical properties, but their electrical conductivities are decreased [106].

2.7 Aim and Scope of the present work

The aim of the present work is to prepare copper based nanocomposite coatings to improve the mechanical and corrosion resistance properties without impairing the conductance of the copper matrix. In this direction, the present work aims to prepare copper nanocomposites incorporated with ceramic nanoparticles...
like TiO$_2$, CeO$_2$ and ZrO$_2$ and conducting nanomaterials like PANI & MWCNTs by electrodeposition method.

The bath variables on the codeposition such as bath composition, current density, codeposit concentration, pH and temperature have to be optimized.

The composition of the electrodeposited copper nanocomposite coatings are to be examined by energy dispersive X-ray analysis (EDAX).

The chemical oxidative polymerization method has to be followed for the synthesis of polyaniline which are to be codeposited with copper from the plating bath.

The crystallite size and structure of the electrodeposited nanocomposite coatings are to be examined by X-ray diffraction analysis (XRD). The surface morphology of the electrodeposited copper nanocomposites are to be examined by scanning electron microscopy (SEM) studies.

The mechanical properties like hardness and wear strength of the electrodeposited nanocomposite coatings are to be studied by Vickers microhardness tester and Taber abrader tester respectively.

The corrosion resistance properties of the electrodeposited copper nanocomposites are to be evaluated in 3.5% NaCl solution by AC impedance and Tafel polarization studies.

Finally, the prepared copper nanocomposite coatings are to be grade based on their enhanced mechanical and corrosion resistance behaviour.
REFERENCES


[38] H.Oguchi, T.Nishiguchi, T.Matsumoto, H.Kanai, K.Utani, Y.Matsumura


[42] R.Schmechel, H.Winkler, XM.Li, M.Kennedy, M.Kolbe, A.Benker,

[43] Yu-JunXue, Xian-Zhao Jia, Yan-Wei Zhou, Wei Ma, Ji-Shun Li,


[45] G.Carac, L.Benea, C.Iticescu, T.Lampke, S.Steinhauser, B.Wielage,


[48] Dongyun Lee, Yong X.Gan, Xi Chen, Jeffrey W.Kysar, Mater.Sci Eng.,A


[53] Beekanahalli Mokshanatha Praveen, Thimmappa Venkatarangaiah


