CHAPTER 1

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Control and regulation of electrical power is generally done by switchgear devices such as relays, contactors, circuit breakers, control switches, motor starters and others [1,2]. These switching devices incorporate electrical contacts whose function is to connect current paths, to carry the current in closed position, to interrupt current and to isolate current paths from each other in a desired manner. Satisfactory functioning of electrical contacts in the form of switchgear components is extremely important as they have great bearing on reliability and performance of electrical equipment and machinery on which they are installed.

Variety of materials were developed and used as contact materials in past including noble metals like platinum and gold; high conductivity metals such as silver and copper; alloys of silver and copper with metals like cadmium, nickel, gold, platinum, palladium, beryllium, tungsten etc Prior to 1930's, development of contact materials for arcing switch devices concentrated mainly on these silver alloys. However, most of them had some limitations such as high cost, low hardness, low wear resistance, high tendency to weld on overloads, inability to withstand high arc intensities etc. To overcome these problems silver-metal oxide (Ag-MeO) composite contacts and silver-refractory metal composites were developed. Appendix A1 gives a brief account of some of the commercially important silver-base contact materials.

In silver-metal oxide composite group, the silver forms the matrix and the oxide phase forms discrete second phase particles that are dispersed in silver matrix. The dispersed oxide phase improves the silver matrix in two ways- first it increases the hardness of the composite material in a manner similar to dispersion hardening of other oxide-dispersed metal matrix composites like SAP and TD-nickel. Secondly in the region where contact welding occurs, the dispersed oxide phase particles behave as slag inclusions and greatly reduce sticking and welding of contacts.

The different silver-metal oxide composite contacts ,commonly known as single -oxide type contact materials developed around 1960-1980 were Ag-CdO, Ag-MgO, Ag-BeO, Ag-NiO, Ag-GeO_2, Ag-CeO_2, Ag-SnO_2, Ag-CuO, etc. [3]. Among all these systems, Ag-CdO offered promise as a contact material owing to its low arc erosion rate, low welding tendency, fast arc-extinguishing characteristics and low contact resistance. In view of this, Ag-CdO has been used as contact material for low to medium duty arcing contacts in the current range of few amperes to over 3000 Amp. at voltage levels upto 1000 volts and particularly for inductive load circuits.

Despite excellent switching performance of Ag-CdO, extensive research started around 1970 onward in the direction of developing non-CdO type silver-metal oxide contacts. This is attributed to increasing environmental regulations in Japan and USA by agencies like OSHA and EPA on use of cadmium because of its toxic nature. The fact that vaporization of cadmium oxide during switching would be detrimental to human health; leading to chronic diseases like hypertension, malfunctioning of kidneys and carcinogeneity, its use in contact materials is banned by health organizations in some parts of the world. Appendix-A2 gives toxicity data of cadmium and cadmium oxide. Because of the toxic properties of cadmium, replacement materials have been sought for last 10-15 years[4-6].

As a result of this, various non-CdO systems such as Ag-SnO_2, Ag-GeO_2, Ag-NiO, Ag-CuO, Ag-ZnO, etc. have been developed or under development. Of all these systems, Ag-SnO_2 with or without additive has been the choice of research workers in this field as a substitute to Ag-CdO because of its superior resistance to arc erosion and anti-welding properties attributed to higher thermal stability of tin oxide, besides its non-toxicity[7,8]. However, higher thermal stability of tin oxide gives rise to higher temperature rise due to concentration of tin oxide on the contact surface following arcing and thus poor contact resistance property. A couple of additives like In_2O_3, WO_3, MoO_3 or WC have been successfully tried to lower the contact resistance or temperature rise [9,10]. However, such ternary systems are expected to pose manufacturing problems from compositional homogeneity view point.

As regards the electrical performance, of the Ag-MeO type of contact materials it has been reported in the literature that the dispersion of oxide phase in silver matrix and the morphology of oxide phase play a major role in governing the electrical contact properties viz.- contact resistance, arc erosion resistance and resistance to welding of contacts on make & break [11]. As a consequence of this, a variety of powders and processing techniques like internal oxidation processes, coprecipitation method, electroless coating process, freeze-drying route; in addition to conventional P/M process of blending or mixing ; have been developed or under development.

The present investigation has been concerned with exploring the possibility of developing Ag-ZnO material as a non-toxic substitute to more conventional Ag-CdO contact material. A comparative study involving processing, structure and property evaluation for a few commercially important Ag-CdO systems and their respective equivalent Ag-ZnO systems has been undertaken.

1.1 Objectives :

The main objectives of the present investigation are:

* To explore the possibility of replacing CdO by non-toxic ZnO in Ag-MeO type electrical contact materials
* To synthesize and prepare Ag-CdO and Ag-ZnO composite powders by different processing routes for comparison purpose
* To carry out characterization of these powders by techniques such as AAS,XRD, SEM, ESCA, DTA/TGA, laser diffraction, etc.
* To consolidate the above powders using P/M technique of pressing, sintering, repressing/ hot pressing to near theoretical density.

* To evaluate physical, mechanical, microstructural and electrical properties of developed compacts.
* To investigate the effect of alloying on properties of Ag-ZnO contact material.
* To study the effect of degree of dispersion of oxide phase on properties of contact material
* To establish structure-property corelationship in different Ag-CdO and Ag-ZnO systems under study.

1.2 Scope of the work :

(i) Synthesis of Ag-10wt% CdO, Ag-12 wt%CdO and Ag-15 wt %CdO as well as Ag-7.1 wt%ZnO, Ag-8.6 wt%ZnO and Ag-10.8 wt%ZnO powders by different processing routes such as conventional P/M route involving mixing/ blending,spray-coprecipitation process, electroless coating technique, freeze-drying route and mechanical alloying.

(ii) Characterization of above powders by XRD,SEM, AAS, ESCA etc. to examine their morphology, phase analysis and purity.

(iii) Consolidation of powers by pressing, sintering, repressing and hot pressing to high density compacts.

(iv) Evaluation of physical, mechanical, microstructural and electrical properties of compacts.

(v) Investigation of the effect of Lithium addition on Ag-ZnO system.

(vi) Fabrication of test set-ups for life testing of contacts in AC and DC mode and to carry out the life testing.