LITERATURE REVIEW:

The first patents with regards to dust preparation by using spray pyrolysis night started five seven decades ago (T. Suntola, 2002). Subsequently a lot of scientific tests are actually performed about spray pyrolysis running of okay powders since the process helps high-purity, un-agglomerated, nm-sized particles being produced along with homogeneous compound arrangement. During synthesis the answer is usually atomized to be able to droplets that happen to be approved by means of some sort of provider fuel circulation through a diffusion dryer, then the molsysis reactor lastly some sort of calcinations central heat. Inside diffusion dryer, the actual droplets undergo solvent evaporation, precursor precipitation, and also drying. The actual dried precipitate particle decomposes within the thermolysis reactor developing some sort of microporous particle. These kinds of particles are then sintered within the central heat calcinations through the aerosol can. It may possibly be acquired by means of spraying this precursor powder under right conflagration. These kinds of technologies are recently reviewed by (Pratsinis S.E., 2008)

(Brinker and Hurd et.al. 2010) have got reviewed this aerosol pyrolysis approaches in terms of process details in which handle this formation associated with powders. Squirt pyrolysis ends up with particles along with morphologies along with porous and stable materials can be obtained. It was figured that these components and the precursor could highly influence the particle morphologies.

Figure 2. Powdered ingredients generation.
(Chen and Nasrallah et al. 2003) have used this flame-assisted ultrasonic aerosol pyrolysis method to get ready YSZ powders that has a small particle-size distribution. (Messing and Zhang et al. 2003) as well as (Brinker and Hurd et al. 2010) have got exhibited an critical requirements with the activity associated with fine, stable circular particles can be which brought on sodium doesn't experience plastic-type material deformation or maybe burning through heating, due to the fact this kind of brings about this formation associated with covers associated with reduced permeability. Therefore, the remainder solvent can be entrapped in the key in the drying droplet leading to a boost associated with stress, as the solvent cannot quickly evaporate throughout the layer. As a result, this layer fractures producing extra minute droplets along with broken layer artifacts which leads to be able to powders associated with abnormal condition. The particular creators of these studies in addition figured substantial sodium solubility seriously isn't necessary for this formation associated with stable along with uniform particles seeing that in the past explained by (Brinker and Hurd et al., 2010)

(Gurav and Kodas et al., 2004) as well as synthesized (Bi, Pb)-Sr-Ca-Cu-0 powders using aerosol pyrolysis from 900°C, which included a lot of nano-particles (< 25 nm). The improved results were later experimentally verified and patented by (Mochel. J.M., 2007) Grp composite powders along with 10 wt% Ag that had been created from 700°C contained 20-60 nm grains associated with metallic along with mixed-oxide levels that has a fine dispersal of Ag grains inside particles that has been believed to be able to great with regard to finalizing Bi-cuprate superconducting material.

- **Slim film depositing along with applications**

Films made by the particular squirt pyrolysis approach are actually employed in different devices e.g. solar panels, devices, antireflection coatings, thermal coatings, sound oxide gasoline solar cells, and there are others. This segment summarizes the particular functionality of the devices and the picture depositing employing squirt pyrolysis.

Slim film depositing while using squirt pyrolysis approach will involve spraying some sort of metal sodium answer on top of some sort of excited substrate (Figure 3). Minute droplets effect on the particular substrate exterior, spread right computer designed construction, along with experience thermal decomposition. The particular shape and size is
dependent upon the particular energy along with number of the particular droplet, and also the substrate temperatures. For that reason, the particular picture is generally consisting of overlapping drives associated with metal sodium currently being transformed into oxide on the excited substrate.

![Figure 3. Schematic associated with squirt pyrolysis gear.](image)

- **Films regarding solar cell application**

  Transparent as well as executing oxide films seeing that house windows inside solar panels had been served by spray pyrolysis. Concept geared up remarkably see-through zinc oxide films about cup substrates (Hill and Chamberlin et al., 2004). The components of the transferred films might be different as well as governed by simply modifying your spray guidelines, your deposition temperature as an example has impact on your optical as well as electro-mechanical components involving zinc oxide films (Balkenende and Bogaert et al., 2006). Films with all the most affordable electro-mechanical resistivity were being transferred applying aqueous option involving zinc acetate at 490°C due to advancement involving crystallinity, though films geared up at 420°C as well as 490°C showed excessive transmitting (90-95%) in the visible range.

  This was due to your loss of your video fullness as well as improves in the structural homogeneity. The precursor option is definitely an essential practice adjustable. (Caillaud and Smith et al., Arya and Hintermann et al., 2003) emphasized on the effect on of pH on the slim film deposition as well as articulated that the development rate of thin films
does depend upon the PH values. The rate ended up being solely major if $3.5 < \text{pH} < 4.3$. Within this pH range vaporized precursors are found to have the zinc acetate complexes. Enhancement involving standard salts, adsorption materials, or maybe precipitates slowed down the development at increased PH. With reducing PH values, the quantity of zinc acetate along with the development rate lessens until eventually negligible deposition takes place.

Transparent SnO$_2$ electrodes have been placed through squirt pyrolysis utilizing tetra-α-butyltin (IV) as precursor. The particular deposition productivity and also crystallinity in the shows placed at 300°C ended up being improved with the help of H$_2$O$_2$ on the alcoholic precursor solution. The particular experts suggested two answers due to this influence. The first ended up being in which H$_2$O$_2$ decomposes easily on the substrate to produce a oxygen atmosphere which in turn advances the oxidation associated with tetra-w-butyltin and also decreases residuals within the film. The next ended up being in which H$_2$O$_2$ and also tetra-w-butyltin together with primary atomic bonding. This sort of design is actually attractive, intended for enhancement associated with SnO$_2$.

The particular physical attributes associated with fluorine-doped indium oxide shows have been looked into regarding deposition heat range, dopant attention, fresh air charge and also film thickness by (Mooney and Radding et.al., 2002). It had been discovered that this deposition heat range includes a outstanding impact around the positioning in the shows. The particular degree associated with preferential $(4 0 0)$ positioning improves together with improving film thickness.

> **Receptors**

Propane receptors provide semiconducting precious metal oxides of which change electric conductance in the existence involving carbon monoxide in addition to e.g. hydrocarbons. The sensor typically is made of a good oxide semiconductor film by using an insulating substrate along with a couple precious metal electrodes affixed. Container oxide is just about the most widely used oxides because of this application. Park prepared container oxide shows on goblet substrates of analyzed since receptors for CH$_2$Cl$_2$ in oxygen (Tomar and Garcia et.al. 2011). SnO$_2$ thin films shows along with high certain region for NO$_2$ receptors happen to be put into the account using the spray pyrolysis strategy (Sceduler and S.H. Zuing
et al., 2007). LaOCl-SnO₂ shows manufactured by electrostatic spray deposition strategy have demonstrated guaranteeing sensing components for LASER throughout air flow by (Pamplin, 2009).

Porous SnO₂ in addition to SnO₂-Mn₂O₃ shows are prepared using the electrostatic spray deposition strategy by (Patil P.S., 2009). These types of shows had been employed in hydrogen receptors. The grain dimension from the porous film ranged from 1 um, meters to help 10 um. It had been seen the grain dimension will increase that has a higher concentration of the precursor in the ethanol solvent. The SnO₂-Mn₂O₃ (10:1) mixed oxide films showed sensitivity to hydrogen.

Some metal oxide sensors show sensitivity to humidity. The influence of process parameters on the sensitivity to humidity of SnO₂-Fe2O₃ films has been investigated (Bohac and Gauckler et al. 2007). The nature of the iron salt influenced the humidity sensitivity of the samples. The films deposited from an alcohol solution containing Fe₂(C₂O₄)₃ exhibit higher sensitivity than a solution containing Fe(NH₄)(SO₄)₂. This fact was explained by the higher porosity of the structure obtained from iron oxalate, because during the oxalate pyrolysis a lot more gaseous decomposition products are released compared to the sulphate precursors.

Thin SnO₂ films for gas sensors have been prepared also by spray pyrolysis using an inorganic as well as an organic precursor solution (J. Aman, 2008). Suitable electric properties were measured for films obtained from the organic solution. The deposition temperature was either 60°C with a subsequent treatment at 250°C for one hour or between 150°C and 450°C. The sensitivity and rise time were found to depend on the deposition temperature and the type of precursor solution used. The best results were achieved by spraying an organic precursor solution onto a substrate at about 300°C.

It was observed that the growth rate of SnO₂ films prepared from SnCl₄-5H₂O was higher and their resistance lower in comparison with those of films prepared from anhydrous SnCu (Pratsinis S.E., 2008). The authors suggested that under identical conditions, the droplets containing SnC₁₄-5H₂O require more thermal energy to form SnO₂ than
those containing SnCu. Thus the water molecules seemed to influence the reaction kinetics, particularly the growth rate of the films.

- **Metal oxide coatings**

  Titania films have been deposited on steel to prevent corrosion using titanium isopropoxide as the precursor (Messing and Zhang et al. 2003). Three different configurations for film deposition were used. In the first configuration, the precursor vapor impinges on the substrate. In the second configuration, small droplets of the precursor solution impact onto the substrate. In the third configuration the droplets pass through a high temperature region, where solid Titania particles are formed and subsequently deposited on the substrate. In all cases the substrate was moved at a velocity of 1 mm/s to 1 cm/s perpendicular to the spray direction. Dense, adherent films were deposited using the first and the second configuration whereas porous films were obtained using the third configuration. The highest deposition rate was achieved when the droplets impact on the substrate surface. 500 nm thin titania films offered protection against corrosion at room temperature.

  MgO thin films are commonly used as buffer layers. Thin, uniform, and homogeneous layers of MgO were deposited on Si (100), fused silica and sapphire (Djurado and Meunier et al.). These thin films (0.1 to 0.5 µm thick) are used as buffer layers for depositing films of YBa₂Cu₃O₇. (Yuan and Chen et al. 2008) have studied the influence of additives on the properties of MgO films deposited by electrostatic spray deposition. A large number of separated particles were observed on the surface of MgO films when pure THF was used as a solvent.

  However, smooth and particle free MgO films were deposited when 1-butyl alcohol or 1-octyl alcohol was added to THF. The authors suggest that the alcohols effectively restrain MgO nucleation resulting from the vaporization of droplets. The type of solvent did not influence the crystallinity of the films. (Soveski et al., 2007) deposited 0.2 pm thin alumina films by spray pyrolysis using aqueous acetic acid solution of Al acetylacetone (Zhang and Messing et al., 2010) Al₂O₃ is used in electronic devices as a thin insulating layer. There was no voltage breakdown observed up to 10 V of applied potential.

Films developed applying thermal decomposition may cause voltage breakdowns at 3 V. It was concluded that films deposited using spray pyrolysis exhibit high quality and higher breakdown
voltages than those prepared by traditional deposition. Even better quality insulating layers with breakdown voltages higher than 30 V were formed on silicon substrates (Liu and Sakurai et al. 2006)

Fuel cells

Thin YSZ films have already been deposited by spray pyrolysis on the following substrates: glass (Gurav and Kodas et al. 2004), aluminum (Aranovich and Ortiz et al. 2009), steel (Afify and Nasser et al., 2001) and porous La(Sr)CoO₃ cathode (Caillaud and Smith et al., 2003). (Okuya and Kaneko et al., 2011) deposited calcia-stabilized Zirconia (10%) onto porous La₂Sr₀.₄Mn₀₃ cathode substrates.

Terbia-doped thin films have been deposited using electrostatic spray deposition (Mirzapour and Rozati et al. 2004) the surface morphology was controlled by changing the deposition parameters and solution compositions. By increasing the deposition temperature, the morphology of the film was shifted from a dense to a highly porous structure.

The electrostatic spray deposition technique has been used to prepare films on substrate. Most of the thick layers were porous or cracked, but dense thin layers were found under cracked top layers. Even so, some of the cracked films may also be used as a composite electrolyte, because the cell containing the material-coated ceria electrolyte exhibits a higher open circuit voltage than those with ceria alone (Mirzapour and Rozati et al. 2004).

A suspension of YSZ powder with an average grain size of 0.2 urn was sprayed onto an apressed Ni/YSZ anode substrate and a layer of 10 um was obtained in 3 minutes. However, a subsequent sintering step was required. In the next step, the cathode was prepared similarly. In such case, the MnO₃ powder was added to a solution of strontium acetate, lanthanum nitrate and manganese nitrate. A thin cathode was deposited at 500°C and subsequently annealed at 900°C for 2 hours. This was tested at 550°C.

The open circuit voltage was lower than the theoretical value due to the presence of pinholes in the thin film electrolyte. Consequently, the maximum power density was only 107 mW/cm² at 550°C (Afify and Nasser et al. 2001). To our knowledge only few reports on fuel cell tests have been presented. A FC cell with a Ni-YSZ anode /10% electrolyte /
Lao.6Sr0.4Mn03 cathode arrangement has been tested by (Okuya and Kaneko et.al, 2011). The tests were performed using hydrogen as fuel and oxygen as oxidant. The open circuit voltage of the cell with 33 urn thick CSZ film deposited at 100°C was 0.96 V and the maximum power density 600 mW/cm2 at 1500°C. The cracks in the film were eliminated by repeated coating since the voids of every coating step are filled by subsequent spraying steps.