CHAPTER 5
CONCLUSIONS

Following conclusions can be drawn from the research work done for this thesis.

1. Refluxing time as well as precursor modification results in differences in the morphology of resultant Titania nanoparticles.
    - For Tit samples:
        - 24hr reflux: rod like structures (width 1 micron, length 5 microns)
        - 70 hr reflux: mixed rod like and spherical particles (various sized)
        - 120 he reflux: spherical particles (diameter around 500nm)
    - For Ta samples:
        - 24 hr reflux: more or less spherical nanoparticles (around 50 nm)
        - 70 hr reflux: “emerging spikes”(thickness100 nm, length micron range)

2. Refluxing time and precursor modification does not effect the composition and phase of the resulting product and exclusively anatase phase is obtained.

3. Refluxing at 100^{o} C results in production of only anatase phase of titania which is rare.

4. The crystallite size is not much different in all the samples (i.e. in the range 5.0 to 10 nm); the little increase on annealing is satisfactory.

5. In as prepared samples nanoparticles are observed for titania obtained from acetyl acetone modified precursor after both 24 hour (Ta 1) and 70 hour (Ta 2) refluxing. But for Tit 1,Tit 2 and Tit 3 the sizes were not in nano range. The spheres obtained for Tit 3 were in the size range of 500nm. The rod like structures has width around 130 nm but their length is in micro range.

6. The films were made from Tit 1, Tit 2 and Tit 3 because very well dispersed spherical particles were observed in two of these samples. Although in Tit 2 rods were present but the structures had distinct well formed geometries. The dried powders of all three samples do contain nano sized particles.

7. The SEM results after annealing of the films Tit 1, Tit 2 and Tit 3 reveal very good morphologies.

    a. The film Tit 1 shows high porosity and proper connectivity among the nanoparticles (~20nm) but at micro level the film has got cracks and is not continuous.

    b. Tit 2 film has cracks at micro level which are quite large besides also at nano level the morphology is not desirable for using it in DSSC as the photoanode. The nanoparticles are visible but they are in clusters. The porosity is almost absent in these films at nano level.

    c. The best results of the three film kinds are observed for Tit3 films. The films are continuous at micro and macro level with almost no cracks and also at nano level high porosity is observed around 50 nm sized nanoparticles. These films can be used in making photoanode of the DSSC.

8. A prototype DSSC cell was assembled and tested. The DSSC indicated current when tested. at light intensity of 100mW/ cm^2. it was just a try towards making of better cells

9. For growing 1-dimensional nanostructures anodic alumina templates were to be produced on TCO coated glass by first sputtering an Al film and then its anodization. But analysis after Al deposition revealed that there are structures in micron size range. So, anodization could not be done. Further experimentation over this will be done in future.

CHAPTER 6

FUTURE RECOMMENDATIONS

Following future work needs to be done for improvement and further development of present results.

6.1. SYNTHESIS OF NANOPARTICLES:

For better understanding and control over the synthesis process a better insight of the process need to be obtained during and after the nanoparticles production process, to actually see the extent and limit of modifier bonding with Titanium metal in various steps of the synthesis process, so that a better speculation of the morphology obtained under different conditions may be made. This can be done by stepwise taking FTIR spectra so that absorption bands of acetate or acetyl acetonate group will tell the extent of their presence in the product.

Also the compositional analysis by EDS can be used to study the change in percentage of carbon present at different stages like after water addition, then after peptization and then during and after the refluxing process, to see when actually does the precursor modifier get detached from Ti.

6.2. SINTERED FILMS:

For Tit 1 film sample very nice results were obtained at the nano level but improvement in the film continuity at micro and macro level is needed in order to make the film efficient as photoanode use. This can be achieved by varying the paste constituents' ratio, and thus optimizing a paste composition to give a film with micro and nano level continuity along with the perfect porosity to offer high surface area to the semiconductor film of photoanode of our future DSSCs. It would be great if above objective is accomplished because 120 hours is quite a long period to obtain the present best results (Tit 3 films) so we need to optimize whole of the 24 hr process, till the production of the films, for better economy.

6.3. PRODUCTION OF 1-D NANOSTRUCTURES:

To make anodic alumina templates over TCO coated glass for growing 1-dimensional nanostructures of titania or any other wide band gap semiconductor we need to deposit a better aluminium film in terms of grain size and thickness of the film. We can have a film with better control of morphology if deposit a thinner film. Also sputtering rate and other conditions need to be optimized in order to obtain better films to be used in making nano templates.

Another option is to use some alternate method for growing 1-D structures on the TCO coated glass for example using electro assisted methods.

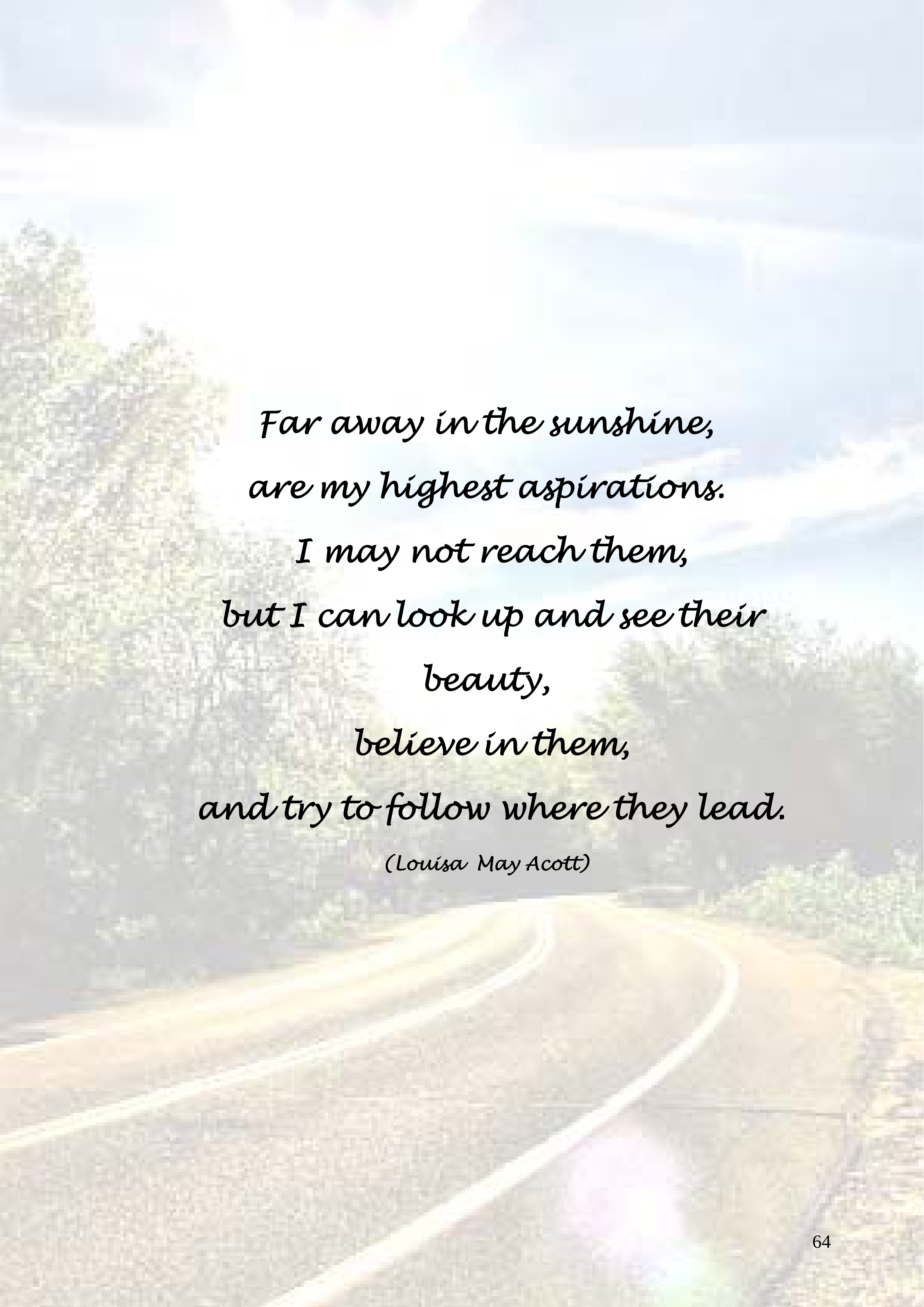
6.4. COLUMNAR ALUMINIUM FILMS:

The morphology of the columnar Aluminium films obtained in the present work is quite unique and interesting, it can be tried to make those reproducible. Such Aluminium films can be used to make Al_2O_3 rods by the oxidation of Aluminium and can be used for many applications.

6.5. MAKING DSSC:

The main big goal is to develop highly efficient low cost DSSCs. We need to develop and acquire facilities at SCME for the testing of solar cells for example a solar simulator, a source meter etc.

Sincere and passionate efforts in this field would result in achievement of the goals (InshaAllah).



Far away in the sunshine,

are my highest aspirations.

I may not reach them,

but I can look up and see their beauty,

believe in them,

and try to follow where they lead.

(Louisa May Acott)

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