

**PREPARATION AND CHARACTERIZATION OF ULTRA-THIN FILMS  
CONTAINING Au AND Ag NANOPARTICLES USING LAYER-BY-LAYER  
DEPOSITION TECHNIQUE**

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**IN PARTIAL FULFILLMENT OF THE REQUIREMENTS  
FOR THE DEGREE OF  
MASTER OF SCIENCE**

**By**

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**July 2009**

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## **ABSTRACT**

### **PREPARATION AND CHARACTERIZATION OF ULTRA-THIN FILMS CONTAINING Au AND Ag NANOPARTICLES USING LAYER-BY-LAYER DEPOSITION TECHNIQUE**

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**M.S. in Chemistry**

**Supervisor: Prof. Dr. Şefik Süzer**

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The main objective of this thesis is to investigate the layer-by-layer deposited polyelectrolyte and polyelectrolyte/metal nanoparticle films by using X-ray Photoelectron (XPS) and Optical Spectroscopy (UV-Vis).

Within this purpose, in the first part of the study, layer-by-layer deposited single and oppositely charged bilayered films are investigated by XPS. To extract additional information in the molecular level, the samples are analyzed while applying an external voltage bias. It is shown that applying external electrical stimuli to a single polyelectrolyte layer coated Si/SiO<sub>2</sub> system responds to the change in the polarity by molecular rearrangements, evidenced by the changes only in the intensity of the corresponding -N<sup>+</sup>(1s) peak.

In the second part of the study, metal nanoparticle (Au and/or Ag) incorporated polyelectrolyte films are investigated by optical spectroscopy. Within this frame, multilayer gold and silver nanoparticle/polyelectrolyte films are prepared both separately and in bimetallic form. In order to get further understanding about the optical responses of single type of metal nanoparticle incorporated systems, several experimental approaches are followed. These approaches also enable us to control and manipulate the optical properties of these compact structures.

The last part focuses on incorporation of metallic ions into layer-by-layer assembled polyelectrolyte matrices through ion-exchange method. It is shown that metal ions can be incorporated and subsequently reduced within this polymer matrix by UV or X-ray irradiation and can also form nanoparticles.

**Keywords:** Layer-by-Layer Deposition, Polyelectrolytes, Au and Ag Nanoparticles, Surface Plasmon Resonance, Interlayer Interparticle Interaction, Ion-Exchange, XPS.

## ÖZET

### KATMAN-KATMAN KAPLAMA YÖNTEMİYLE Au VE Ag NANOPARÇACIKLARI İÇEREN ULTRA-İNCE FİLMLERİN HAZIRLANMASI VE KARAKTERİZASYONU

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Bu tezin ana amacı katman-katman kaplama yöntemiyle kaplanan polielektrolit ve polielektrolit/metal nanoparçacık çiftlerinin X-ışını Fotoelektron (XPS) ve Optik Spektroskopi (UV-Vis) yöntemleriyle incelenmesidir.

Bu amaç kapsamında, çalışmanın ilk kısmında katman-katman kaplama yöntemiyle kaplanan tek ve zıt yüklü iki polielektrolit katmanlı filimler XPS yöntemiyle incelenmiştir. Ayrıca, moleküler düzeyde daha fazla bilgi edinebilmek amacıyla, örneklere dışarıdan voltaj uygulanmıştır. Si/SiO<sub>2</sub> alttaşı üzerine kaplanan tek bir polielektrolit katmanı dışarıdan elektriksel olarak uyarılmış ve bu sistemin değişken polariteye bağlı olarak moleküler olarak yeniden düzenlendiği, ilgili -N<sup>+</sup>(1s) tepeciklerindeki intensite değişimleriyle kanıtlanmıştır.

Çalışmanın ikinci kısmında, metal nanoparçacık (Au ve/veya Ag) dahil edilmiş polielektrolit filmleri optik spektroskopik yöntemle incelenmiştir. Bu

çerçevede, çok katmanlı altın ve gümüş nanoparçacık/polielektrolit filmleri ayrı ayrı ve bimetalik formlarda hazırlanmıştır. Tek tip nanoparçacık dahil edilmiş polielektrolit filmlerinin optik özellikleri hakkında daha fazla bilgi edinebilmek amacıyla, birkaç deneysel yaklaşım takip edilmiştir. Bu yaklaşımlar bize aynı zamanda bu çok katmanlı yapıların optik özelliklerini kontrol etme ve yönlendirme olanağını sağlamıştır.

Çalışmanın son kısmı iyon değişimi yöntemiyle metal iyonları dâhil edilmiş katman-katman kaplama metoduyla hazırlanmış polielektrolit matrislerine odaklanmıştır. Metal iyonlarının sisteme ne derece dahil edilebildiği, UV ve/veya X-ışınlarına maruz bırakılarak polimer matrisi içerisinde indirgenmesi ve nanoparçacık oluşumu ile incelenmiştir.

**Anahtar Kelimeler:** Katman-Katman Kaplama, Polielektrolitler, Au ve Ag Nanoparçacıkları, Yüzey Plasmon Rezonans, Katmanlar Arası Etkileşim, XPS.

## LIST OF ABBREVIATIONS

LbL: Layer-by-Layer

LB: Langmuir-Blodgett

NP: Nanoparticle

PAH: Poly(allyamine hydrochloride)

PEI: Poly(ethylenimine)

PMMA: Poly(methyl methacrylate)

PSS: Poly(sodium 4-styrene-sulfonate)

QCM: Quartz Crystal Microbalance

SAM: Self Assembled Monolayer

SEM: Scanning Electron Microscope

SPR: Surface Plasmon Resonance

UV-Vis: Ultraviolet-Visible

WCA: Water Contact Angle

XPS: X-ray Photoelectron Spectroscopy



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