計畫編號：10

計畫名稱：電子束實驗室與光電產業建立合作平台的先導性研究

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計畫中文摘要：

電子束實驗室為台灣大學奈米製程中心所屬實驗室，對建立產學合作，將奈米科技推廣到產業界，扮演重要角色；本計畫中我們預定與艾司摩爾公司合作發展一個技術平台，由於我們先前已成功利用電子束微影技術製作奈米結構增加金屬與半導體界面接觸面積，改善界面電導的問題，並研究出不需退火的低溫製程，也能在界面形成良好歐姆接觸。我們首先以這些在奈米接觸研究發展的初步成果應用於氮化鎵發光二極體元件之特性改良，首先是接觸問題之改善，再經由設計適當奈米結構來控制量子點產生的位置，藉以加強元件電流展佈，進而使元件發光更能達到近白光效果。另外，我們預計以先前發展的離子高敏感度交流電訊量測技術，配合表面電漿子和金屬光柵的特性，建立生物測試晶片的平台，以電子束機台設計金屬光柵結構使凹槽處為微電泳通道，生物分子水溶液均勻滴加於凹槽，光柵兩端連通成電極，外加交流訊號可測知電場是否影響生物分子行為，進而改變光學量測結果。由本研究群近來以理論計算出訊號增強的效果大約在一萬倍數量級。預期經由適當的週期設計，可使金屬環境內聚集能量，不需要很強的光源，也可得到強度足夠的放大訊號，如此可以準確標的出生物分子的特徵光學響應，預期可大幅改善訊號鑑別度。而在奈米光傳輸的最後一個進程，我們將逐層在氧化物中設計多重疊合的絕緣光柵，研究其穿透、反射及電學相關特性，此種多層結構具有類似光子晶體特性，其功能亦可與光子晶體相比擬，且製作容易，為電子束機台可製作。

而為了使奈米級的製程精確度更加提升，在上述構想執行同時，我們也同步在電子束機台的自動控制方面致力於最新的研究。隨著微影製程中光罩上之關鍵尺寸日漸縮小下，顯而易見的製程中對關鍵尺寸之量測技術需求則大幅上升，現今常見一般使用之三種關鍵尺寸標準量測法，包含原子力顯微鏡、掃描式電子顯微鏡與傳統光學式顯微鏡，往往於這三種量測法之結果無法得到一致之數據，而造成此現象之原因可能係因對材料參數特性知識了解不全或模組準確性不足所導致，其中光學顯微鏡解析度不足亦為因素之一，伴隨關鍵尺寸縮小這些量測之間差異越是顯見。所以本計畫預計採用散射量測法於量測

光柵線關鍵尺寸，而首要條件須擁有標準之量測樣品，如 45 奈米半間距、 32 奈米半間距與 22 奈米半間距之量測樣品。不同關鍵尺寸預期採用電子束微影搭配相關製程設備與最佳化參數來製作，預計在於製作樣品的過程，由於關鍵尺寸已屬 45 奈米等級以下，為達製程可重複性與穩定性，需要具備相當之半導體製程經驗及搭配優異之儀器來完成相關參數之設定與定奪。完成後預計搭配上原子力顯微鏡、掃描式電子顯微鏡或穿透式電子顯微鏡來驗證樣品之關鍵尺寸，以備日後散射量測法所需之量測樣本進而完成製程中對關鍵尺寸測量學之技術需求。

計畫英文摘要：

Keywords: Electon beam lithography, ohmic contact, nanocontact, current spreading, surface plasmon, grating, microelectrophoresis channel, multilayer, critical dimensions (CD), scatterometry, CD metrology.

Electon beam laboratory is a part of NTU Nanofabrication Center, which plays an important role in establishing cooperation and spreading nanotechnology to the industry. In our proposal, we decide to develop a technical platform with ASML. According to our past successful experiences in improving metal-semiconductor contact conductance（MSCC）by using electon beam lithography to design nm-scale trenches, we have developed a low temperature process without annealing, which can form a fine ohmic contact same as thermal-treated process. First we demand to apply our preliminary results of the development of nanocontact on the GaN-based LED characteristics improvement, like contact problem. By properly designing nanostructures, we can well control the sites that quantum dot generates to improve the current spreading, further achieve the near-white light efficiency. In addition, we decide to establish a platform for biomolecule detection based on our previously development like high-sensitivity AC signal measurement technology, combine with surface plasmon and the property of metal grating. We design the grating structures, which the trenches are turned into microelectrophoresis channel. Biomolecule solution is added uniformly in the trench environment. The two extremities of gratings are shorted as electrodes.We can realize whether the biomolecular behavior will be influenced via adding AC electric signals, further change the optical spectrum.According to our recent theoretical calculation, the optical signal enhancing factor is about 104 order. We predict that by properly design of grating pitches, the energy could be locally confined in the metal environment.Therefore, the sufficient intensity of amplified signals could be acquired without strong optical source, which can precisely mark the characteristic optical responses of biomolecules and substantially improve the signal identifications.At the last phase of naoscale optical transmission, we will fabricate the multilayer insulating gratings which are embedded in the oxide layers. Then we will study the property of transmission, reflection, and related electrical properties. The multilayer gratings possess properties of photonic crystals, and the functions are more comparable. Besides, it is easy to fabricate, which can be produced of e-beam lithography.

In order to improve the accuracy of nanoscale fabrication, we simultaneously make efforts in the latest study about the automatic control of the electron beam machine as the above project proceeding.With decreasing critical dimensions (CD) on lithography masks, increasing demands on CD metrology techniques come along. Already today the results of the three standard methods for CD measurements currently used, atomic force microscopy (AFM), scanning electron microscopy (SEM), and optical microscopy, typically do not yield the same results. This is because of, e.g. incomplete knowledge of the material parameters, insufficient modelling accuracy or － especially in the case of optical microscopy － insufficient resolution. With decreasing CDs these systematic differences increase. Scatterometry has been most commonly applied to CD metrology of line/space grating structures. However, for the process development and control of 3D structures for contact hole lithography applications, the current metrology methods of CD-SEM, electrical CD (ECD) and/or cross-sectional SEM (X-SEM) produce the desired information either (a) as an incomplete solution, (b) too late in process flow, or (c) in a destructive manner. In this research, we will present use cases for the application of scatterometry to the 45nm, 32nm and 22nm － HP line/space calibration samples. These calibration samples were achieved by E-beam. The purpose of the research was show that E-beam can be used successfully to fabricate 45nm, 32nm and 22nm － HP line/space calibration samples. Analysis tool of scatterometry modelling precision and matching results are also shown, which indicate the stability of the measurement process, and correlation to CD-SEM, AFM and TEM are also provided as reference CD metrology.