Extension of KrF Lithography to Sub-50 nm Pattern Formation

Shuji Nakao, Jiroh Itoh, Akihiro Nakae, Itaru Kanai, Takayuki Saitoh, Hiroshi Matsubara, Kougirou Tsujita, Ichirou Arimoto and Wataru Wakamiya
ULSI Development Center, Mitsubishi Electric Corporation
4-1 Mizuhara, Itami, Hyogo 664-8641 JAPAN; e-mail: snakao@lsi.melco.co.jp

ABSTRACT

Sub-50 nm isolated line pattern is successfully formed by KrF lithography with DOF larger than 0.5 μm. This is performed by using a phase edge type phase shift mask, a special photo resist and a partial dry ashing process. Because all of these elemental techniques currently becomes mature, this method is one of promising candidates for sub-50 nm isolated line pattern formation. As a conclusion, we consider KrF lithography can be extended to sub-50 nm high speed logic node.

Keywords: Sub-50 nm isolated line pattern, Phase edge type PSM, Special resist, Partial plasma ashing, Low MEF

1. INTRODUCTION

Optical lithography using an phase edge type phase shift mask (PE-PSM) is the most promising lithography technique for formation of fine gate pattern of logic devices. Many works have been reported on this issue 1-7. H. Y. Liu et. al. 2 and S. Hatta et. al. 3 have shown significant improvement of intra-field CD uniformity by this technique. Sub-100 nm pattern formations have been presented for the application to actual devices fabrication 4,5. Moreover, some companies have announced industrial production of devices with gate length of ~100 nm utilizing this technique. CAD venders have prepared a software which generates mask patterns with combination of optical proximity correction (OPC). In several works on this technology, special type resists, the characteristics of which are tuned for fine isolated line formation, were used. Utilizing such kind of resist, line pattern can be formed with smaller width than that defined from optical image by the slice level method 6,7. In some cases of such processes, small but finite dissolution rate for unexposed part is essential for the CD characteristics 7.

However, when pattern is formed with conventional wet development, the pattern size is limited to ~70 nm because of resist pattern collapsing or peeling during development process. Therefore, this technique can be applicable to a line whose width is larger than ~70nm. On the other hand, shrinkage of resist pattern width by dry (O2 plasma) ashing has been proposed as a production process for sub-150 nm pattern formation by H. Kawakami, et. al. 8. They have shown that process uniformity was so high that no difference in intra-200 mm wafer line width variation was observed between before and after 50 nm shrinkage process. Thus, this method considered to be applicable to extreme fine pattern formation utilizing PE-PSM.

In this paper, we will propose a lithography process module for sub-50 nm line pattern formation by KrF exposure. First, process procedure in this method will be described. Then, experimental results will be shown. The merits of this method will be demonstrated and discussed.