# Bragg grating filters in plasmonic V-groove waveguides

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**Abstract:** We demonstrate spectral filtering via Bragg gratings in plasmonic V-groove waveguides. Transmission spectra of wafer-scale fabricated devices exhibit 8.2 dB extinction ratio with 39.9 nm bandwidth. Near-field measurements verify spectral rejection.

**OCIS codes**: (050.2770) Gratings; (240.6680) Surface plasmons; (230.7380) Waveguides, channeled

## 1. Introduction

Surface plasmon polaritons (SPPs) – electromagnetic excitations that propagate along the surface of a dielectric-metal interface – have received increasing interest during the last decade due to technological advances that allow metals to be routinely structured and characterized on the nanoscale. SPPs offer unique attributes to the field of applied optics due to their ability to concentrate light below the diffraction limit [1]. This forms the underlying principle concerning the development of numerous SPP-based subwavelength guiding components where the cross-section of the guiding structure may be orders of mangitude smaller than the wavelength of light. However, to date a configuration with strong confinement and sufficiently low loss has been elusive.

Channel plasmon polaritons (CPPs) are thought to be most suitable to optimize the trade-off between lateral confinement and loss. In this regard, plasmonic V-shaped waveguides are a distinctly promising candidate, where CPP modes may be bound to propagate along the bottom of the metal groove [2]. V-groove CPP properties have been shown to offer wide ranging advantages in terms of confinement and loss suitable for both the downscaling of photonic circuitry [3] and the integration of plasmonic components within lab-on-a-chip sensors. Yet while V-grooves offer tremendous potential, their substantive implementation is dependent on improved device assembley, both in terms of structure quality and fabrication throughput, as well as continued sophistication.

In this work we develop a process for producing plasmonic V-grooves with state-of-the-art Bragg grating filters (BGFs), depicted in Fig. 1, that incorporates wafer-scale nanoimprint lithography (NIL). In contrast to previous work by Volkov *et al*. [4] where a V-groove BGF was created by focused ion beam (FIB) milling, we form the grating corrugation and V-groove simultaneously using nanoimprint processes with a pre-defined e-beam lithography patterned silicon stamp. The technique avoids some of the drawbacks inherent to FIB milling and represents an extension of earlier results that reported on the parallel process fabrication of devices containing smooth sidewall V-grooves using NIL technology.

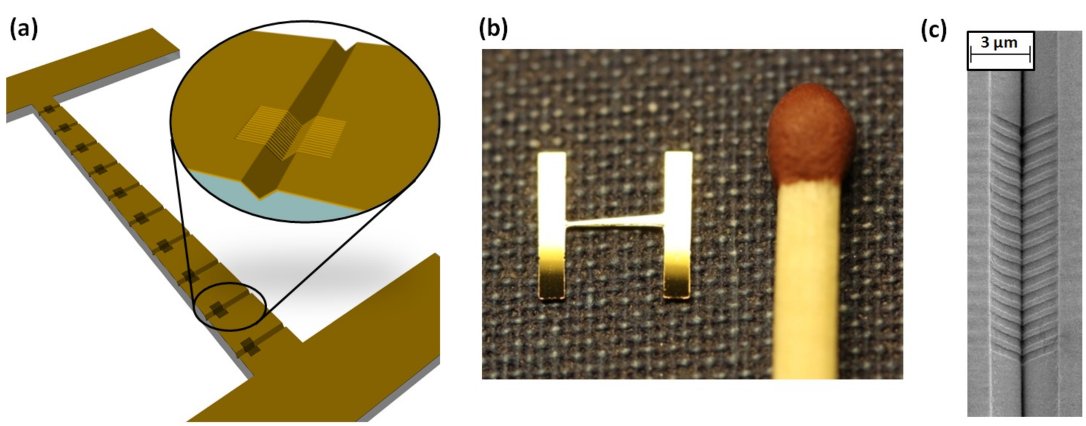


Fig. 1. (a) Illustration of a device with zoom-in of a V-groove containing a Bragg grating filter. (b) Photograph of a fabricated device beside a common match. (c) Scanning electron micrograph of a fabricated V-groove with 16-period Bragg grating filter.

## 2. Characterization of devices

We characterize our devices using both transmission measurements and near-field scanning optical microscopy (NSOM). Two polarization-maintaining single-moded lensed optical fibers are used for launch and collection in an end-fire configuration. The source is transverse-electric polarized (TE-like with the e-field mostly parallel to to the device surface plane). In order to determine exclusive coupling to a CPP mode, either NSOM scanning or far-field observation of the light intensity exiting the V-groove end facet is required.

The optical transmission through a 311 μm-length V-groove containing a 16-period BGF is plotted in Fig. 2(a), exhibiting a 8.2 dB extinction ratio and a −3 dB bandwidth of $\Delta\lambda$ = 39.9 nm near telecommunications wavelengths. In the inset the reference transmission through a similar but grating-less V-groove (no BGF) in dBm scale is shown. As can be expected, longer wavelengths propagate further along the V-groove – i.e. lower propagation loss – due to decreasing confinement to the metal.

NSOM measurements for a V-groove with the same parameters above are shown in Fig. 2(b). The scanning field regions are 5.0 μm × 27.9 μm, A cross-section of an atomic force micrograph (AFM) indicates where the BGF corrugation occurs. It is clear that rejection of the propagating light occurs for $\lambda$ = 1465 nm as it interacts with the grating corrugation, while for $\lambda$ = 1550 nm this effect is reduced. The extinction ratio, $I_o/I_i$, is found to be 4.5 ± 0.9, where $I_i$ and $I_o$ are taken before and after the corrugation at 8 μm and 23 μm propagation coordinates respectively. The uncertainty is related to measurement noise. It is clear that the optical signal reduces quickly within the BGF region, indicating that a smaller number of periods would suffice to provide reasonable wavelength rejection.

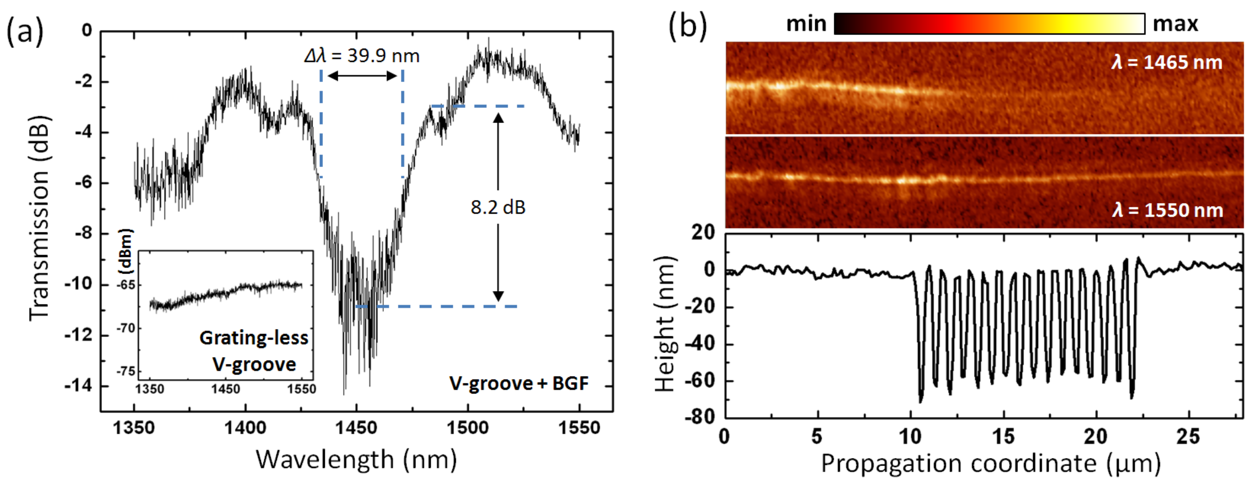


Fig. 2. (a) Transmission measurement of a V-groove containing a 16-period BGF. Inset: reference transmission through a similar but grating-less V-groove. (b) NSOM measurements for two different wavelengths ($\lambda$ = 1465 nm and $\lambda$ = 1550 nm) showing the spectral rejection for the former. An AFM cross-section shows the corresponding profile along the propagation direction.

In summary, we demonstrate spectral filtering via high quality Bragg gratings in plasmonic V-groove waveguides. Transmission spectra of wafer-scale fabricated devices exhibit an 8.2 dB extinction ratio with a −3 dB bandwidth of $\Delta\lambda$ = 39.9 nm. Near-field scanning measurements verify spectral rejection. The findings represent an important milestone towards a sophisticated, mass-production-compatible application of plasmonic V-grooves suitable for purposes ranging from photonic circuit miniaturization to lab-on-a-chip sensing.

## 3. References


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