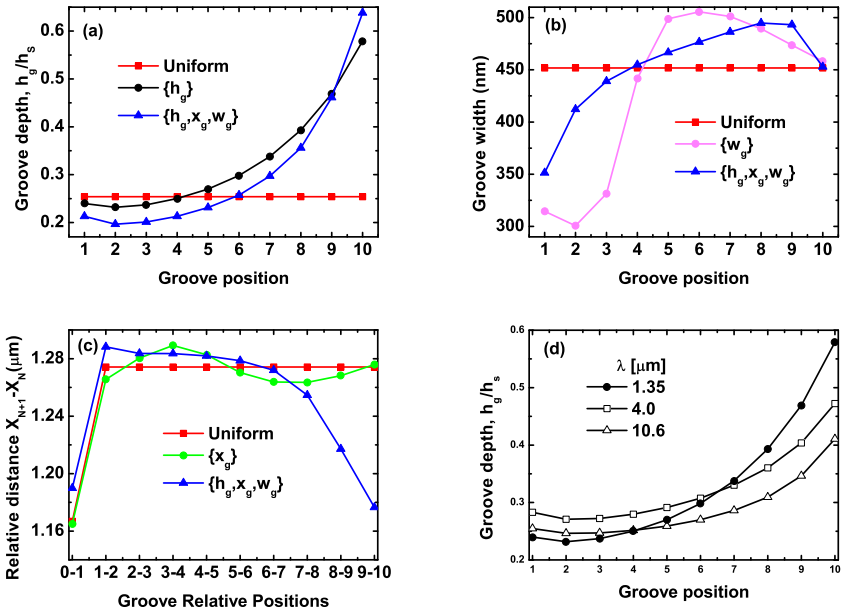

Fig. 5. Profiles obtained for $\lambda = 1.35\ \mu$m in the CG optimizations of the uniform and nonuniform SGAs. (a) Profiles of groove depths. (b) Profiles of groove widths. (c) Profile of groove positions. (d) Groove profiles as a function of λ.

5. Conclusions

In search for high efficiencies in the light harvesting process of a one-dimensional slit-groove array, we have considered the interplay between Fabry-Perot modes of a single slit and groove cavity modes of the groove array. We have developed the following simple design rules for a uniform SGA, that are valid for optical and IR frequencies.

- Fabry-Perot and groove cavity modes should be at the same spectral position. For sub-wavelength apertures at a given λ, the position and intensity of the Fabry-Perot is controlled by metal thickness and aperture size, respectively. The spectral position of the groove cavity modes is mainly determined by groove depth and pitch.
- The normalized-to-area transmittance grows monotonically with the number of grooves, given that grooves move apart and become broader and shallower as N_g increases. In particular:
  - The ideal periodicity (P) is slightly smaller than the SPP wavelength (λ_{spp}). P tends to λ_{spp} (from below) when more grooves are added to the SGA.
  - Slit-nearest groove distance should be about $0.92P$ (but only for the optimal P).
  - The ideal groove depth is smaller than half of the metal thickness. This quantity decreases with the number of grooves (N_g).
  - The optimal aspect ratio decreases with λ but raises with N_g.

We also account the following trends for the optimal system:

#173250 - $15.00 USD Received 25 Jul 2012; revised 2 Sep 2012; accepted 6 Sep 2012; published 25 Oct 2012

- The transmission efficiency of a uniform SGA in the infrared is practically independent of λ.
- In contrast, the relative enhancement provided by a nonuniform SGA decreases with λ. A chirped groove array enhances the transmittance between 15% and 39% for decreasing λ.
- The bandwidth decreases with the size of the system.

Summing it up, we hope that our findings could motivate further theoretical and experimental studies of light harvesting structures.

Acknowledgments

The authors gratefully acknowledge financial support by European Projects FP6 PLEAS project Ref. 034506 and EC FP7-ICT PLAISIR Project Ref. 247991, and the Spanish Ministry of Science and Innovation project MAT2011-28581-C02-02.

#173250 - $15.00 USD Received 25 Jul 2012; revised 2 Sep 2012; accepted 6 Sep 2012; published 25 Oct 2012