Direction of arrival (DOA) estimation methods based on joint sparsity are attractive due to their superiority of high resolution with a limited number of snapshots. However, the common assumption that signals from different directions share the spectral band is inappropriate when they occupy different bands. To flexibly deal with this situation, a novel wideband DOA estimation algorithm is proposed to simultaneously infer the band occupation and estimate high-resolution DOAs by leveraging the sparsity in the angular domain. The band occupation is exploited by exerting a Dirichlet process (DP) prior over the latent parametric space. Moreover, the proposed method is extended to deal with the off-grid problem by two schemes. One applies a linear approximation to the true dictionary and infers the hidden variables and parameters by the variational Bayesian expectation-maximization (VBEM) in an integrated manner. The other is the separated scheme where DOA is refined by a postsearching procedure based on the reconstructed results. Since the proposed schemes can automatically partition the sub-bands into clusters according to their underlying occupation, more accurate DOA estimation can be achieved by using the measurements within one cluster. Results of comprehensive simulations demonstrate that the proposed schemes outperform other reported ones.